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PROCEEDINGS

OF THE

THIRTY-FIFTH ANNUAL GENERAL MEETING,

EDINBURGH,

JULY 19—21, 1916.

The Thirty-fifth Annual General Meeting of the Society of Chemical Industry was held in the Hall of the University Union, Teviot Place, Edinburgh, on Wednesday, July 19th, 1916.

At the outset the Chair was taken by the Lord Provost of Edinburgh, Sir ROBERT INCHES, who said:—

"It gives me very great pleasure to come to the opening of the Annual General Meeting of the Society of Chemical Industry and, on behalf of the Corporation, to offer you a hearty welcome to the capital of Scotland. I recall the fact that your Society visited Edinburgh in July, 1894, when Sir James Russell was the occupant of the Civic Chair. The meetings on this occasion will take the form of a Congress on the progress which has been made in British Chemical Industry since the war began. To demonstrate to some extent the real progress which has been made, there will be an exhibition of certain classes of chemical products, some of which were not made in Great Britain prior to the war, while in other cases these exhibits are designed to show the great progress that has been made. While Edinburgh is not a great industrial centre, there are a number of important chemical industries in the district, amongst which may be mentioned glass making and paper making, and one or two new industries which have been started since the war began. Specimens of the products of these industries are also to be on exhibition. A Section of the Society for the East of Scotland was formed in Edinburgh a little over a year ago, and at the end of its first session it has now the honour of welcoming the members of the Society to Edinburgh at this time."

The PRESIDENT then expressed to the Lord Provost the cordial thanks of the Society for the great honour he had done them in attending the meeting and welcoming them. He felt that the compliment was one which the Lord Provost desired to pay not only to themselves but to the great and important industry which the Society represented. He was sure that reminiscences of the first meeting of the Society in Edinburgh, to which he had referred, had greatly influenced them in arriving at the determination to come again.

The LORD PROVOST thanked the President for what he had said and left the chair, which was taken by the President, Dr. CHARLES CARPENTER.

The Acting Secretary then read the Minutes of the Meeting which took place at Manchester last year, and these were confirmed and signed by the President.

On the motion of Mr. E. V. EVANS, seconded by Mr. WHELDON, Mr. J. W. Tait and Dr. H. G. Rule were elected Scrutators for the ballot in respect of the election of Members of Council.

REPORT OF COUNCIL.

The Report of Council was then read, as follows:—

During the year the Council has held 11 meetings, Accounts Committee 10, Publication Committee 24, Information Bureau Committee 10, Annual Reports on Applied Chemistry Committee 4, Triple Joint Committee 3, Special Joint Committee 2, and Catalogue Committee 2, also a Conference on Paper Supplies.

The number of Members now on the Register is 4059, as compared with 4017 last year. Since the last Annual Meeting 301 new Members have been elected, and the losses have been 259.

The losses by death amount to 62, viz.:—J. M. Aitken, J. W. Aylsworth, C. Barzano, John Brock, H. Brunner, W. Cairns, M. Cannon, C. A. Catlin, A. R. Clarke, Bryan Corcoran, Arthur J. Dickinson, Wm. B. Duffus, Peter Dunn, J. L. Foucar, Elton Fulmer, John Fyfe, W. B. Gerland, Guido Goldschmiedt, John Grindley, Arthur Harris, Jos. W. Harris, Arthur Haydock, Thos. Hill-Jones, Christopher Hodgson, Edward Jackson, Wm. G. Johnston, Georg E. Kind, E. Lequin, Ivan Levinstein, Vivian B. Lewes, John G. Lyon, G. D. Macdonald, Isidor Magnus, N. H. Martin, Raphael Meldola, A. Dominguez Miralles, Walter Nelson, Andrew Noble, T. L. Patterson, A. R. Pechiney, Kenneth Pelmore, D. J. Playfair, Henry Pollard, Edward Rhodes, F. J. Richardson, Henry E. Roscoe, John Salamon, J. I. Smail, Ewing Smith, F. O. Smithers, W. M. Sowerby, David Spence, W. Stanley, F. W. Stoddart, A. Vorisek, G. Wachtel, W. R. Waterfall, G. Weddell, E. W. Wheelwright, E. E. Wilkinson, J. Murray Wilson, Corbet Woodall. Sir Henry Roscoe was the first President of the Society, Mr. Levinstein was President from 1901 to 1903, and Prof. R. Meldola was President from 1908 to 1909. Major J. L. Foucar died of wounds, and Messrs. Jos. W. Harris and Walter Nelson were killed in action.

Four Ordinary Members retire from Council, and to fill the vacancies thus created, eight nominations have been received, a ballot will therefore be taken.

The following Chairmen of Local Sections retire:—Prof. J. Watson Bain (Canada), Prof. Henry Louis (Newcastle), Dr. W. M. Grosvenor (New York), Mr. John White (Nottingham), Prof. C. E. Fawsitt (Sydney), and Mr. F. W. Richardson (Yorkshire). The following have been elected to succeed them:—Mr. T. H. Wardleworth, Mr. H. Peile, Mr. Jerome Alexander, Dr. R. M. Caven, Mr. H. G. Smith, and Prof. J. W. Cobb. Dr. Alex. Rule, Secretary of the Liverpool Section, retired shortly after the last Annual Meeting, and was succeeded by Dr. Alfred Holt. The Council desires to express its thanks to the retiring Officers for their services to the Society.

The Balance Sheet and Annual Statement of Accounts, which have already appeared in the June 30th number of the Journal, will be laid before the Meeting.

The Journal in 1915 contained 1276 pages of text as compared with 1230 in 1914.

The Committee appointed in November, 1914, to consider the foundation of a Permanent Bureau to assist and advise in the consolidation of Chemical Industry in the Empire, has been actively engaged during the past Session on the necessary preliminary work. A register of the members of the Society and their occupations, on a more elaborate scale than the List of Members, published annually, is nearly completed, and the Committee has had under consideration the formation of a register of chemicals and allied manufactures, and of the manufacturers of chemicals and chemical plant, based on the classes in which abstracts are arranged in the Journal. The Committee also proposed that steps should be taken to stimulate the manufacture of chemicals not made in this country by drawing together the manufacturers in their respective classes; to collect and distribute information from foreign countries as to the supply of and demand for chemical products, raw materials, and plant, and to obtain reports of new markets, fiscal changes, and patent regulations; and to encourage inquiries from Government Departments, British Dominions, Consular Agents, etc.

as to the demand for and supply of chemical products, plant, and raw materials. As it appears possible that some of these matters are such as will be dealt with by the proposed Association of Chemical Manufacturers referred to below, it has been decided to defer further action for the present.

On November 4th a joint meeting of the Councils of the Chemical Society, Society of Dyers and Colourists, and this Society was held to consider the best methods for promoting co-operation among chemical manufacturers themselves, and between them and the teachers in Universities, Colleges, and Technical Schools, and also for initiating and prosecuting researches in connection with the scheme of the Advisory Council for Scientific and Industrial Researches. On the recommendation of this meeting a Triple Joint Committee of the three Societies was appointed, and later drew up a scheme for carrying out these objects. This scheme was submitted, on May 23rd, to a meeting of representatives of over 100 of the principal chemical manufacturers, at which it was decided to form an Association of British Chemical Manufacturers.

The President and Council of the Royal Society on May 22nd convened a conference to organise scientific effort in this country. At this conference a Conjoint Board of Scientific Societies was constituted, for the furtherance of the following objects:—Promoting the co-operation of those interested in pure or applied science; supplying a means whereby scientific opinion of the country may, on matters relating to science, industry, and education, find effective expression; taking such action as may be necessary to promote the application of science to our industries and to the service of the nation; and discussing scientific questions in which international co-operation seems advisable. The Society of Chemical Industry is represented on this Conjoint Board by Sir George Beilby and Sir Boverton Redwood, Bart.

The Council has addressed to the Advisory Council for Scientific and Industrial Research a request for a grant in aid of a research to be carried out by Mr. J. Huebner at the Municipal School of Technology, Manchester, on the changes which cellulose undergoes during certain technical operations. The request has, however, not yet been granted. It is unfortunate that there should have been hesitation in supporting a research which promised to be of considerable technical value and was put forward on the deliberate recommendation of the Council of this Society.

During last year a Joint Committee of the Chemical Society and this Society was appointed to receive suggestions and inventions in connection with the prosecution of warfare on land, for transmission to the Inventions Department of the Ministry of Munitions. This Committee furnished to the Ministry suggestions which there is reason to believe were found useful.

The Society has been in communication with the Royal Commission on Paper and Pulp Supplies with a view to the removal of the restrictions on the consumption of paper by Journals of Learned and Technical Societies, but the Commission was unable to grant any relief in this respect. It has therefore been necessary for the Society to condense as far as possible all matter appearing in the Journal.

The Council has approved a scheme for the issue of periodical Reports of the Progress of Applied Chemistry. These Reports should tend to increase the value of the Journal by presenting a series of expert reviews of the various industries.

A Committee of the Council, appointed on the motion of the Liverpool and Manchester Sections, is engaged in the preparation of a catalogue of scientific and technical Journals and Patent literature to be found in the Libraries of this country. It is hoped that this catalogue will shortly be available for the use of members.

The Council has appointed a Committee to report and advise the Board of Agriculture on the disabilities under which manufacturers are labouring owing to the present method of estimating the fertilising value of slags from their solubility in citric acid.

A large number of copies of the August 31st issue of the Journal were lost when the S.S. "Hesperian" was sunk by a submarine. The Council arranged for a special reprint of this issue to replace the lost copies.

The changes made in the character of the Annual Meeting at Manchester last year, involving the substitution of the reading and discussion of papers dealing with subjects of great general interest, for many of the functions of a purely social character, were eminently successful, and the Council notes with great satisfaction that the Committee of the Edinburgh Section has arranged the programme on similar lines this year.

An invitation to hold the next Annual General Meeting in Birmingham will be laid before the meeting.

In order to bring the Council into close touch with the Sectional Committees, it was decided to hold two meetings of the Council each session in provincial centres; the February meeting of the Council was accordingly held in Liverpool. It was also decided to hold in each Session conferences of the Chairmen and Secretaries of the various Local Sections.

Messrs. H. Hemingway and D. Lloyd Howard were elected to fill vacancies in the Council caused by the resignation of Sir Hugh Bell and the election of Dr. Charles Carpenter to the office of President, and Sir F. L. Nathan has been elected to fill the vacancy caused by the death of Mr. N. H. Martin.

Messrs. E. V. Evans and W. J. Rees and Prof. G. T. Morgan have been elected members of the Publication Committee, and Messrs. D. L. Howard, T. D. Morson, and A. Gordon Salamon members of the Accounts Committee.

Mr. C. G. Cresswell, who had been Secretary of the Society since 1884, having resigned, the Council has awarded him a superannuation allowance of £300 per annum. In response to advertisement for a successor, the Council has received ninety-eight applications, and after consideration of these decided to appoint Dr. J. P. Longstaff at the salary of £600 per annum.

Dr. J. T. Dunn moved the adoption of the report. As a former member of the Council he had some knowledge of the way in which the business was conducted. He had a very pleasing recollection of the meetings and of the devotion of the members to the work. During the present year the Council had had an unusually arduous time and it was a matter for congratulation that the Society had a body of men who had so devoted themselves to the interests of the Society.

Mr. F. H. Carr seconded the motion, and endorsed what Dr. Dunn had said of the arduous nature of the work of the Council. The effect of that work was sincerely felt and appreciated by the members.

The motion was put to the meeting and adopted unanimously.

Report of Hon. Treasurer.

The Hon. Treasurer, in presenting the financial statement, said that the balance sheet as printed in the Society's Journal of June 30th differed very little from the preceding ones. In 1914 there was an excess income over expenditure of

£894 15s. 2d., and in 1915, of £997 14s. 5d. So far as the investments were concerned there was that unfortunate element which accompanied most investments, namely, depreciation, and, unfortunately, that depreciation had not ceased. The valuation of the investments in 1914 was £18,693 4s. 8d., a depreciation of £2314 15s. 7d., or 11% on the purchase price. The valuation in 1915 was £19,755 18s. 1d. and the depreciation £2943 4s., or nearly 13%. The investments were increased by the purchase during 1915 of £1700 of war stock at 4½%.

The depreciation was considerable, but it compared very favourably with that shown by some mercantile concerns as well as in institutions in which investments were treated much as in our own. In the case of one undertaking in London, managed by financiers of note, the depreciation had been no less than 16½% for 1915. They were frequently reminded in the Council that they should progress, but progress was impossible without money, and the question of means was one which concerned the Council very much and gave the officers most concerned a considerable amount of anxiety. The Council had great pleasure in submitting the accounts, and hoped that they might be favourably received by the Society.

The PRESIDENT said that the amount of attention given by the Hon. Treasurer to the financial affairs of the Society had been found of the very greatest value by the Council. So long as the balance sheet bore upon it the two statements, one showing the various investments and the other the valuation at which they stood at the moment, it could not be regarded as other than a true and fair statement.

Mr. W. F. REID moved the adoption of the balance sheet and accounts, and at the same time proposed a hearty vote of thanks to the Hon. Treasurer, who had taken so much care in preparing the report. He had rendered yeoman service to the Society in his very careful and accurate conduct of their financial affairs. Very few realised the work which he had to do. When it was considered that there were over 4000 members, each member had to pay a subscription and there were several entries for each man, that all that money had to be dealt with and operated upon a number of times, it would be realised that he had an enormous amount of detail to carry out, especially during the early part of the year, and they ought to be deeply grateful to a man of his commercial ability for the devotion with which he applied himself to their affairs. When presenting his financial statements to the Council he always put into their minds the thought that however much they might wish to extend the scope of the Society's operations, they were necessarily limited by the financial aspect. It was a matter of great gratification to them that the Council was able to present so favourable a balance sheet as it had done. He had much pleasure in moving the adoption of the accounts and the vote of thanks to the Hon. Treasurer for the work which he had done on behalf of the Society.

Mr. R. D. PULLAR, in seconding the motion, emphasised the request for a special vote of thanks to the Hon. Treasurer. As one who had been present at the first Annual Meeting and at many since, he thought the Society was to be congratulated on having such a Treasurer. They had had during all those years continuity in the management of their finance, and he felt sure that their finance was in perfectly safe hands.

The resolution was carried with acclamation.

The HON. TREASURER briefly thanked the meeting for their vote.

PRESIDENT'S ADDRESS.

The PRESIDENT then read his Address as follows:—

I must preface the brief remarks I desire to address to you by a well-deserved acknowledgment of the obligation under which the Society finds itself to its youngest, the Edinburgh, Section who are our hosts to-day. I believe we may regard our gathering in such circumstances as a happy augury for the future. As we run over the names of those large cities of the Kingdom where it has been our custom to hold these meetings, they stand out most prominently as centres of industry and commerce where Art and Science have found modern dwelling places. But the "Athens of the North" claims our homage essentially as an ancient seat of learning, spiritualistic rather than materialistic, a more congenial soil for the study of *belles-lettres* than for researches in dye-stuffs. If Art and Science mutually need inspiration from each other, then our meeting together in Edinburgh cannot but be fruitful in good results.

Foremost among our thoughts here must be consideration of the relationship between the educational and the industrial problems. Three aspects of this seriously concern us. First, I would place the need of recognition by the professors of learning of the necessity to the Country of a Cultured Industrialism. Second, the acceptance by Industry of the faith that only through Science can it develop and prosper. Lastly, but not least important, the understanding by statesmen that neglect of these principles will be as deadly to the nation as disregard of its health or morals. When the effect of bounty-made sugar in damaging what was once a flourishing British industry was pointed out to Gladstone, he retorted "make jam." He would not have uttered that remark had his knowledge of industry been comparable with his mastery of Greek. And this takes us straightway to the root of our difficulties, "Does the education of our statesmen properly fit them for the posts they are destined to occupy in the management of this great Empire?"

How many of them would not have given Gladstone's answer to a similar question put to them two years ago? It came as a rude shock when but a few weeks after war was declared, they woke up to the fact that whatever our jam resources may have been we were lamentably deficient in powder. Fate had unhappily made it impossible for us to rely upon the same source of supply as we fell back upon in our last great struggle. Of what help to our statesmen was familiarity with the Trojan War, the Punic wars, or any of the great conflicts of ancient times, in the mortal combat in which we have been engaged for the past two years? The industrial sciences are now the dominating factors, not cleverness in classics, and slowly the nation is becoming alive to this fact. Is it not time, then, that our educational houses were set in order, and that the atmosphere with which they are permeated and by which the best of the nation's youth is so largely imbued, was charged with other ideals? Is there not in our mother tongue an adequacy of classic thought and expression to provide exercise and food for the developing mind?

Now this is where the Edinburgh Section of our Society can play an important part. The University is celebrated throughout the world, and attracts students from all parts. It possesses the great advantage that the city has a substantial voice in its counsels. What a step forward would be gained if it could be inspired to take upon itself the responsibility of placing Science in the forefront of its teaching; if among all the older institutions it set the example in a change which sooner or later is bound to come over the spirit of teaching, if we are to hold and maintain our

place among the nations! Surely Physical Science deserves, nay, demands, to-day a place in the scheme of education, along with that of morals, and coupled with such languages that one may read first-hand its story-books, and find inspiration in the records of its far-reaching discoveries and the paths followed by explorers in their seeking. Its meditations, too, are always healthy, never morbid, whether pursued in the laboratory or the study.

The suggestion has been put forward that the mental characteristic of our race does not fit it to become expert in the science of organic chemistry. In my humble but considered opinion this is a fallacy. I believe there is no reason why we should not attain eminence therein as we have in, let us say, seamanship or shipbuilding. Our youth, however, needs an apprenticeship on land, as earnest-compelling as that afloat, where carelessness brings speedy retribution. There are no doubt many scores of students who have a natural capacity for organic chemistry, had but fate willed its exercise, or there had been its atmosphere in our educational centres as of sea-salt at our ports. But, it will be asked, will our manufacturers avail themselves to the full of the services of skilled chemists; are they not already too often disappointed by results? Certainly they will be disappointed again and again, if they only call them in when in trouble and expect them to wave successfully a magician's wand over their recalcitrant processes. There are two main difficulties to be encountered in transferring laboratory work to the large scale. One is its economics; the other its practicability. Most people are aware that to extract gold from sea-water is a proposition financially faulty. Chemists need too often to be reminded that though a process may be pretty it does not attract a manufacturer unless it is sound. Some of the most beautiful productions of the lathe are those in which from a block of ivory are fashioned a whole range of objects one within the other up to the very core. But the utility of such an operation is easily thrown into the shade by the output from a simple piece of apparatus used for making circular the treads of railway wheels. As part of the training of chemists, careful attention should be given to the matter of costs, by setting problems for research in which definite prices are allowed for the raw materials to be used. In addition to this, values should be fixed for the various operations involved, such as distillation, ordinary or vacuum, filtration, crystallisation (whether from water or other solvents), centrifuging, and so on. The chemist would thus be trained in the laboratory to the importance of price questions which are certain to arise in the course of his work. He might also be counselled to listen patiently to the so-called practical man, whether leading hand or otherwise, who may be entrusted with the charge of carrying on the large scale work. There is every probability that he may learn something from him, just as there are circumstances at sea when we would feel safer in the hands of a local fisherman than the captain of a Cunarder. The other important factor in setting up large scale and modern processes is the increasing need for the engineer to take an important share in their development. Not only must the process itself be theoretically sound, but industrially sound also. Heat, power, and labour absorbed together with the scale of adaptation and the nature of the plant employed, are matters upon which the trained engineer is peculiarly fitted to give valuable advice with a view to reduce output costs to their lowest level. The engineer may, indeed, be regarded as a no less needful adjunct to the chemist in such circumstances than is the surgeon to the physician in problems pertaining to health. How many chemical inventions have failed to mature because of engineering difficulties attending their development? The mutual obligation to each other of the Chemical and Engineering sciences is an increasing one, and of which a very good example is the synthetic production of nitrogen compounds.

There is yet a third factor to be considered in the pursuit of efficiency, namely, the workmen. For twenty-seven years the undertaking with which I am chiefly associated has practised a system of co-partnership with its employees, very much on the lines of that described in one of the papers read at our last Annual Meeting. The manufacturer who seeks the highest chemical yield and the highest mechanical yield stops short of his goal if he overlooks the part played by labour and does not aim at its highest efficiency also. The chemical worker is as necessary to the well-being of the State as the sailor or the soldier. Yet how many go to their work with the same alacrity and cheerfulness as the latter to their death? The reason is not far to seek; they share the responsibilities and advantages of progression, and their duties and rights are recognised in the supreme councils of the nation. In industry such ideals are unfortunately a long way from attainment. It would take many inventions and much wisdom in management to do for industry what its own labour could, were it but imbued with the idea of how much could each industrial unit turn out, instead of how little. The Company to which I have referred has gone a long way in the direction of realising such hopes, and to-day of its 6800 workpeople, over 6000 are shareholders. Anticipating the not unusual criticism, may I add that while in France no similar undertaking is working under these conditions, they have been largely applied in many other industries. Two practical examples of utility happening within the past fortnight may be interesting. The one is of a leading hand who, expressing the hope that we had made a wise choice in the appointment of a new manager, remarked that all his life's savings were invested in the business. The other is of a corporal just returned from the front where he had been since the outbreak of war, who brought in French notes all his savings of pay to be invested in the Co-partnership. I should like before leaving the debatable ground of Capital and Labour to refer to a practice which, I believe, would be found useful by all employers. It is that of holding inquiries into every industrial accident by juries of workmen (in fatal cases after the coroner's verdict has been given). This has been found very helpful in reducing the number of cases, as well as their seriousness. It must be remembered that efficiency is not only concerned with raw material, but with each unit of human life employed. Necessarily, it is the former point of view rather than the latter which has largely dominated the work achieved by our Society in the third-of-a-century of its existence, and it is interesting to note how the history of Chemical Industry in this Country has been recorded in the pages of the Journal. Its earlier volumes describe the triumphs of those technologists whose names are familiar to us as household words—Weldon, Siemens, Mond, Beilby, Chance, Hurter, Gilchrist, and many others. In later years the progress made by other countries grows more in evidence, outstanding examples being synthesis of indigo and of ammonia, though a notable exception is provided by the labours of Messrs. Cross and Bevan, whose work on cellulose laid the foundation of a large industry.

That the Society has "done its bit," in the parlance of the hour, in the making of the history of Applied Chemistry cannot be doubted. Might it have taken a larger share? It is not easy to answer such a question, despite the opportunities given by time

for the acquisition of belated wisdom. Perhaps its greatest opportunity for what I will call original work might be regarded as not only the bringing together of the expounders of theoretical and the practitioners of technical chemistry, but to have made them such friends that each has gathered understanding from the other. Now, surely, there never existed so suitable a problem for a round table conference as that of the utilisation of the fuel supplies of the Kingdom. No one could possibly quarrel with the description of our coal resources as being the most important of our capital assets. Yet the bulk of the Country is busily engaged either in squandering that capital or bartering it away and living on the proceeds. If water power be looked upon as a national heritage, and such a view is finding increasing favour throughout the world, the arguments in its favour apply with greater force to the deposits of coal, for these are limited despite their greatness, while the falls are inexhaustible. Parliament has already placed under authority our tidal rivers, the use of which is regulated for the common good. Should the development and utilisation of our coal resources be left unrestrictedly to the individual or group of individuals acquiring mining rights, generating energy, or warming their dwellings, or should such matters be subject to State supervision and control? Should the payment of two or three pence per ton be the solitary factor deciding whether or not the nation's coal leaves its shores to be worked up into by-products by the nation's competitors in industry? Could not the large demand for fuel required for metallurgical purposes abroad be met by the export of coke instead of coal, leaving the by-products to be utilised and handled here? Has the time come when the raw coal exported should pay substantial duties to the State, and every user at home be required to satisfy the authorities before he can obtain quantitative licences for its consumption? Will a democratic parliament ever follow the example of an autocratic government and prohibit the combustion of raw coal in our cities and towns? Now that we are at last receiving encouragement in thinking Imperially, problems which seemed stupendous show themselves easy of solution, and what is more, they will compel attention and decision. Certainly that of coal utilisation may well commend itself to our Society. It may be asked "Is not this the case with all matters pertaining to the welfare of Chemical Industry?" I do not so regard them. Take for example, free trade or scientific tariffs; or the attitude of the State in labour matters or in special legislation. While such subjects may be proper ones for discussions by a Society such as ours, it clearly is not in a position to speak on them with a united or even an authoritative voice. It is mainly for this reason that there has recently come into being a new organisation in the shape of an Association of British Chemical Manufacturers. Owing its being to the Chemical Society, and its development to our own, we may describe it as by pure out of applied science, and I believe it will prove worthy of its parentage. Its proposed constitution provides the fullest powers to work with kindred associations on the one hand towards industrial efficiency, and on the other by the encouragement of training and research. And its formation will certainly relieve the Imperial Parliament from such a time-wasting occupation as discussing what restrictions should be placed upon the producers of coal tar who propose utilising its distillates for the preparation of other substances.

If, however, our constitution as a Society does not provide us with facilities for handling problems such as these, there are untilled fields of usefulness ready for the ploughshares of our endeavours, and they are not being neglected. The Council has recently adopted a scheme for the preparation by competent authorities of annual reviews of the progress made in the various branches of chemical industry, classified under the headings familiar to readers of the Journal. Such additions to the Society's undertakings are, however, bound to necessitate expenditure, but I cannot think members would regard with disfavour these and similar proposals even if they entailed a small increase in the annual amount of their investment in its funds. May not indeed this meeting of ours be considered as giving the opportunity once a year, to those attending it, for expressing their technological faith and belief in that science of Applied Chemistry which takes the discoveries of the laboratory and welds them into those might-wielding creations needed by mankind in the evolution which is his birthright? If we are sincere in that belief, and in the share we are to take in its dissemination and propagandism, can we not look forward to one day building our own meeting-house? One of our most able members has already urged upon us the undertaking of such a duty. Those professing the healing art have a worthy home where under one common roof are to be found lecture rooms, a library, a laboratory, and even a tea room, a rendezvous for all engaged in the many branches of medical and surgical knowledge. Many years ago a countryman of this "bonnie" land expressed to me his admiration for the faith the designer of the North Western Railway had in its future when he planned the monumental gateway to it which we know as Euston Station. May it not be hoped that those who live by or through the Chemical Industry of Great Britain will not lightly put aside consideration of the possibilities such a proposal holds out? We want Physical Science, of which Chemistry is after all but a part, recognised as entitled to a place in the teaching of the schools throughout the kingdom. We want provision made for its deeper study by technical and secondary institutions wherever industry is established. We want chairs of chemistry, organic as well as inorganic, at all our Universities, new and old; and the need of these things we must press unceasingly upon those who are entrusted with the duties of Government. But we must build our own temple to the Science among whose votaries we claim to number ourselves, and Chemistry is no less worthy of such honour than are her other sisters in the Arts and Sciences, whose "Cinderella" she has been so long.

Presentation of the Medal.

The President said that he had a very pleasant duty to perform in recognising important work which had been carried on in chemical industry. The special part which this Society was created to fulfil was to promote applied science and especially the application of chemical science. One of the privileges possessed by the Council was that of recommending from time to time that the Medal of the Society be awarded to some person who had shown conspicuous ability in the domain of applied science, and he had much pleasure in announcing that in accordance with that power the Council had decided to award its Medal to Mr. C. F. Cross for his conspicuous services to chemical industry. He specially mentioned, concerning Mr. Cross' work on paper, the value of the fact that he was one of the first clearly to point out the importance of maintaining the quality of paper, especially in those books and documents which were intended to be permanent records; his other great work in cellulose was of course familiar to readers of the Journal through the various papers which he has contributed. On those grounds the Council were unanimously of opinion that he well

merited this award. There had been one difficulty and that was that the power of the Council was confined to awarding one medal in any year, and that medal must be awarded to one person. In this particular case, with reference to much of the work done by Mr. Cross, he was the first to desire recognition of the fact that he had been associated with Mr. Bevan for a very long while. Unfortunately, however, they had only one medal and therefore must bestow it on the person whom they believed to be primarily the person responsible for the great work carried out in the joint names of Messrs. Cross and Bevan.

The President thereupon handed the Medal to Mr. Cross.

Mr. Cross said that the honour which had been conferred upon him in such extremely generous terms, struck right home, and he wished he could find words adequate to convey the emotions which were raised within him. In their own work the only thing which interested them was the truth, the whole truth, and nothing but the truth, and therefore he would be very sorry to claim anything beyond what justified the selection of the Council for this honour. He therefore mentioned that he had had the co-operation not only of his partner, Mr. Bevan, and also of his some-time partner, Mr. Beadle, but of his assistants who from time to time had thrown themselves devotedly into this work, and notably Mr. J. F. Briggs. In regard to the development which had taken place in connection with the artificial silk industry, he indicated what was particularly due to co-operative work on the part of his colleagues. He had been joined in 1897 by Mr. Stearn and his assistant, Mr. Topham, men whose technical work was of ideal thoroughness. Both of them had been, he believed, associated with the late Sir Joseph Swan, in the early days of the incandescence lamp, and what had attracted them to the cellulose problem in the early days was the search for "carbon" for the filaments. They had soon found viscose satisfactory for that purpose and then turned their attention to its use for making textile threads. Between them they had excogitated a thoroughly mathematical conception of the several processes therein involved, namely, the drawing forward at a particular speed, the necessary twist required to enable the compound thread to be handled in the winding and other operations; the integral solution of this complex problem was the vortex of a centrifuge, and the discovery gave a new impetus to the production of the thread. The method was still largely used, and it was only due to those two men to recognise the extreme importance of the work which they had done and which had had the greatest possible effect in developing this industry.

He also mentioned the pioneer work of the Société Française de la Viscose. They had made a success in thread, in film (drawn by a continuous machine and finished in one process), and in massive solid forms of cellulose, by contrast with the meagre results obtained in Germany; they had gone very much further ahead and with very much greater speed and to very much greater final success. In this country the artificial silk was in the hands of the firm which was Samuel Courtauld and Co. and is now Courtaulds Limited. Superimposed upon the chemical industrial side of the work of that firm, there had been a large contribution of true textile invention, which had had the greatest possible importance in regard to the development of the industry and a commerce which was now world-wide. Looking back over the vista of years he was particularly aware of the difficulties which they had encountered, especially that of being between the cross fires of the commercial or financial man whose watchword was secrecy, and the scientific man, whose disinterestedness, perfectly natural and spontaneous, led him always to wish to publish in order that he might communicate what he had found in his laboratory to his fellow scientific men. It took another form in the question whether inventive science was really at root individualistic or socialistic. Possibly it would always remain more individualistic than socialistic, because the source of discovery was in the imagination and emotions, and due to primary contact with things, and he did not know that any corporate body was able to claim much in that respect. They, as disinterested chemists, were always most anxious to take counsel with their brother chemists, and give them the benefit of anything that had impressed them, just as they looked to hear of any new discovery by others at the earliest possible moment. In thanking the President and the Society, he assured them that they felt nothing more than that they had but made a beginning. He thought they might claim to have made a strong beginning, but it was only a beginning. The British textile industry was the most important in the world and the work which they had been able to do must contribute more and more and in an increasing way to the progress and development of the old country.

Professor Armstrong, in proposing a vote of thanks to the President for his address, with the request that he allow it to be printed in the Journal, said that as a Member of the Council he also desired to express their gratitude to him for his conduct in the chair during the past year. The address was full of most valuable constructive allusions. Thus the expression which the President made use of at the outset in saying that what the country needed was a Cultured Industrialism, did absolutely sum up the situation. If they could bring culture in its truest terms into industry they would be saved. Matthew Arnold had summed up the situation years ago in stating that what the country needed was to get *Geist*—a true intelligence. The President remarked that the mastery of Greek was not all that was required: it was a little distressing to see in the papers that, after all the appeals to the country to reform its educational system, a Senior Classic and a Cleric had been appointed as Headmaster of Eton; no more unfortunate step could have been taken, in view of the need of an example to the public schools of what was required. Much had been said of late by Lord Cromer and others as to the value of humanistic studies. Chemists were frequently characterised as opponents of humanistic studies. No more preposterous assertion could be made. Most of them had gone through the classical mill, which had ground so many to pieces; they therefore could appreciate the position of the classic, but he had not the faintest understanding of the position in which the student of science stood. The ordinary humanist, looking at flowers such as were on the table might be struck by their beauty but he had not the least conception how much more they meant to the instructed eye: the volumes of organic chemistry that flashed into view whenever the complexity of their colouring matters and of the processes involved in producing them were thought of. The President had said that physical science demanded to-day a place in the scheme of education, along with that of morals: but was not the true teaching of science the way to develop morals? Mr. Cross had spoken of the scientific man as an idealist and a worshipper of truth but it was because there had been so little true science taught that we were in our present position. Such science must be brought into the industrialism of the future. But it would be useless to teach science more if use were not made of it when

occasion called for it; from this point of view it was most unfortunate that the charge of industrial research had been given into the hands of a poet as chairman and of a gentleman, as chief secretary, whose qualifications were only literary. The President had referred to the connection of chemistry with engineering. He had himself set a wonderful example by entering into association with the chemist and perfecting the process of gas purification from which such admirable results were now obtained. We must realise that the future of industry in this country depended as much upon the workmen as upon the masters and that the workmen should be educated to understand the issues before the country. The support of the workmen would doubtless be required in forcing the Government to take suitable action in questions such as those of fuel economy and of the dye industry. The Society had cause for special congratulation in having had such a President during the past year. Those who had been present at Council Meetings knew with what extreme urbanity and tact he had presided at the meetings. There had been very difficult situations to deal with and he had helped to an extraordinary extent. The Society was very fortunate in that it was to have him as President for a second year. He trusted that the step would form a precedent for appointing Presidents for two years. During the past year it had been decided to prepare and print reports of progress in the various branches of applied chemistry. The idea of these reports was primarily due to one of the latest acquisitions to the Publication Committee, to a colleague and fellow worker of the President, Mr. Evans. In moving the vote of thanks he had no hesitation in asserting that no President had ever done greater service to the Society.

Mr. THOMAS FAIRLEY, in seconding the motion, said he thought that the President's address was somewhat unique in its extreme comprehensiveness. Professor Armstrong's reference to flowers reimnded him that the Author of Christianity itself had said, "Consider the lilies how they grow": that was really an exhortation to study science. Our very best thanks were due to the President, and they welcomed him anew as President for the coming year.

Professor ARMSTRONG put the vote to the meeting and it was unanimously and cordially agreed.

The PRESIDENT thanked the members for their appreciation.

Mr. H. L. TERRY proposed, and Mr. F. W. ATACK seconded, the appointment of Messrs. Feasey & Company, Chartered Accountants, as auditors for the ensuing year at the fee of 30 guineas. The motion was unanimously agreed to.

PLACE OF NEXT ANNUAL MEETING.

Mr. W. J. REES, on behalf of the Birmingham Section, extended a cordial invitation to the Society to hold the next Annual Meeting in Birmingham. Since the last Annual Meeting at Birmingham very important changes had taken place and undoubtedly those changes would considerably enhance the usefulness of the meeting. The Section would use every endeavour to make the next Annual Meeting, if held in Birmingham, as successful as the last.

Dr. G. S. CRUIKSHANKS seconded. The invitation was put to the meeting and accepted unanimously.

The PRESIDENT then proposed a vote of thanks to the Committee of the Edinburgh University Union for the use of the building. They could not have found a more suitable hall for the meeting. It was convenient in itself and conveniently placed, and they were under a great obligation to the University Union. He therefore proposed that the very best thanks of the meeting be given to the Committee for their great kindness in placing their hall and buildings at the Society's disposal.

Mr. E. F. HOOPER seconded, and the motion was carried with acclamation.

RESULT OF THE BALLOT.

The scrutators appointed for the ballot in respect of the election of officers for the ensuing year, then reported that as the result of the ballot Mr. E. V. Evans, Mr. E. Grant Hooper, Mr. R. D. Pullar, and Dr. Alfred Rée had been elected Ordinary Members of Council.

A vote of thanks to the scrutators concluded the meeting and the members adjourned for lunch, which was provided by the Edinburgh Section in the Dining Hall of the University Union.

WEDNESDAY AFTERNOON.

FUEL ECONOMY: A NATIONAL POLICY REQUIRED.

BY HENRY E. ARMSTRONG.

I had no intention of raising the coal question again at this meeting but as I have been asked to fill a vacancy I will venture very briefly to sum up the position in a few propositions.

1. The time for discussion is past—what we need is constructive action. Will this Society take its share, a preponderant share, in dealing decisively with all issues in which Chemical Industry may fairly be considered to be concerned? A wait-and-see policy is no longer possible—some decision must be taken without delay. Up to the present, the outcome of my appeal to the Society at Newcastle has been disappointing; no attempt has yet been made by the Sections to discuss the various issues constructively and the only practical proposal that has been put forward is that of the London Section urging the Council to take the matter into consideration. After several postponements, at the June meeting the Council resolved that each of the British Sections be asked to nominate a representative to a Committee to consider the attitude to be taken by the Society on the question of Fuel Economy. I trust therefore that the matter is now in train.

2. The situation is daily becoming more and more serious. On general grounds of economy, we must desire to utilise our Fuel supplies henceforth in as complete and provident a manner as possible—individual users are sure to move in this direction but there are many ways in which success can only be achieved if concerted and public action be taken. The organisation of power schemes in important industrial areas is probably one of the first subjects to be considered: fortunately considerable experience in this direction has already been gained, especially on the N.E. coast, which can be applied usefully without loss of time.

3. At the moment, not only is coal dear beyond all expectation and procurable with difficulty but we are in face of an absolute shortage of liquid fuel for internal combustion engines and of a shortage of the dyestuffs that are made from various products of the destructive distillation of coal, in the latter case, partly because of a lack of raw material. It is clear that it would be advantageous to carbonise far larger quantities in ovens or retorts and that in future the utilisation of coal will have to be considered not only from the point of view of securing a maximum output of heat energy—it should not be forgotten, also of minimising the nuisances created by the emission of smoke and of acid products—but from the far more comprehensive point of view that coal is to be regarded, not merely as a source of energy but as the raw material

from which both liquid fuel and the primary materials required by the dyestuff industry and other branches of organic chemical industry are derived—not forgetting the high explosives which are playing so dominant a part in the present war; also as the potential source of vast quantities of ammonia, invaluable as a cereal manure, as well as of not a little sulphur.

It is certain that we have little moral right to use coal simply and directly as fuel: from this point of view, should we not memorialise Government at once to foreshadow legislation prohibiting the use of raw coal, as a fuel, at no distant date? I am told that the use of raw coal was stopped in Germany at an early period of the war.

4. Only enthusiasts will think of electricity and gaseous fuel as the sole sources of heat energy; the sane will continue to regard solid fuel as requisite for domestic and manufacturing purposes—in the latter case, at least as a material to be gasified locally. From this point of view, soft coke is necessarily to be regarded as the solid fuel of the future; yet if such be the conclusion, a situation will soon be created that must not be overlooked. Obviously if gas and soft coke be the fuels of the future, the town gas industry, as at present conducted, will need complete reconstruction—the gas works will be called upon to produce both gas and soft coke and to serve as the primary source of fuel supply in its district; moreover, it will almost necessarily be run in conjunction with the supply of electricity. Already the Brighton Corporation have made arrangements for the installation of a coking plant alongside their electrical works, the gas to be used in firing the boilers of the latter; it will be but a small departure to obtain an Act forbidding the use of raw coal in the district which will make the soft coke produced of special value to the town.

5. In my Newcastle paper, I referred to the production of soft coke as still problematic; I was not then aware what had been done to improve Mr. T. Elwell Parker's process, which gave a coke of unexceptionable quality though on far too small a scale to be practicable. In the interval, a gas fired fireclay oven has been devised in which coking can be effected on a satisfactory scale. I am informed that in Germany probably a dozen such plants are in operation which have been erected since the war began, and that the design of these is based upon information derived from the experiments made in this country. Similar plant will soon be in operation in this country near Barnsley, in the centre of the South Yorkshire Coal Field; this will be run in conjunction with an electrical works and a tar distillery. Such being the case, it would seem that the experimental stage is past and that all that is required is independent study by competent authority of the plants referred to when they are in operation.

6. But there are many problems connected with the economical use of coal which must be fully inquired into. It is essential that both the funds and the machinery for such inquiry should be provided without delay. The appointment of a central National Fuel Board to initiate and supervise all necessary inquiries would seem to be the first step that is called for and I venture to think that no better way of obtaining funds can well be suggested than that I have already proposed—*i.e.* a small tax on all coal raised in the country. I hope the Society will be prepared to take action in the manner suggested.

Discussion.

The President said that Prof. Armstrong had put his finger on a very weak point, namely, that many tons of coal were used the whole of the nitrogen of which was absolutely wasted. It was very difficult to foresee the universal use of gas or electric heating, and, in the intermediate stage, some form of solid fuel might be used. How was that to be obtained? The break-down in the coalite experiments had been very unfortunate in many respects. The fundamental idea of Mr. Parker was to carbonise the coal in small cells, and in itself was an admirable one—but when he had put it into practice he was handicapped by the fact that he had been brought up and trained as an iron-founder and so naturally turned his thoughts to making his cells in iron.

Dr. E. F. Armstrong urged that there was still a great deal to be done by manufacturers in economising coal. The best incentive to economy was an increase in price, and from that point of view the present increase—disastrous as it was to many—was a great incentive to economy in the future. The firm with which he was connected had made it a practice for many years to employ a highly skilled chemist entirely to look after their fuel and water supply, and that policy had been more than justified by results. It was a policy worthy of being imitated very largely in British industries, not so much chemical industries, but engineering industries in particular, and by many others of our great industries. He mentioned a case of one firm who had benefited greatly by the installation of a CO_2 recorder. It was only the largest firms who could afford to have an expert for themselves, but it might be possible for half-a-dozen firms in a neighbourhood mutually to engage an expert to look after their fuel and water problems, by which he was sure great economy might be effected.

Mr. R. H. Clayton said that in Manchester quite recently they had obtained statistics as to what the losses due to smoke amounted to; they were so large that he thought he was quite justified in the view that the smoke problem was the most important of all fuel questions. The question of fuel economy in cities could best be dealt with by each city itself, and each corporation should have a Committee to deal with the heating of the house and the combustion of fuel, which was, to his mind, of as much importance as looking after the sanitary arrangements. Each city could work on a system of heating or several systems of heating. If in every town a department were established as suggested, he was sure that systems of heating would be evolved which would give far better results than any legislation suggested by Professor Armstrong.

Mr. A. MacDonald asked how the ash in soft coke was to be got rid of. In Glasgow they had been deeply interested in clearing the smoke from the atmosphere, and one member of the Council was experimenting with a view to producing a coke which would be useful for house fires, but he had found that it contained an excessive amount of ash and had low heating power. The same trouble had been found in similar fuel prepared by a small works in London.

Mr. R. Maclaurin said that the fuel to which Mr. MacDonald had referred was made from cannel coal, hence the large percentage of ash. With a coking coal a smokeless fuel containing not more than 7 or 8% of ash was readily obtained. The chief difficulty he had experienced in the experiments he was conducting at the Glasgow Corporation's Electricity Station, Port Dundas, was in getting a fuel that would not spark. The sparking was due to the coke dropping while red hot into water. By drying, or avoiding quenching the coke in water, a satisfactory smokeless fuel was obtained. In the low temperature carbonisation of coal by his process very satisfactory yields of oil were being obtained. The oil was fairly fluid, and after separation of a resinous portion would be suitable, he thought, for lubricating purposes or for Diesel engines. The oil contained

actically no benzene nor toluene, as was to be pected in a low temperature process. An expected result, however, was the almost entire sence of illuminants in the gas made. In some periments the coal was carbonised by a current hot water-gas, without any external heating, d he had found that the mixed gas given off om the coal in this way seldom contained more an 0·4% of olefines; had the coal given off 00 or 5000 cub. ft. of gas of 700 or 800 B.Th.U., e olefines should have amounted to fully 4%. other low temperature processes he was conneed that considerable decomposition took place, ving rise to the illuminants present in such gas. he absence of illuminants in his process convinced m that smokeless fuel would be manufactured ore economically in electricity stations than at s works. His plant was in two parts. When orking for power gas and smokeless fuel, air and eam were blown into one chamber where they urned the fuel added to ash and, the gas passed om this chamber into a second chamber, which as practically a large water sealed producer, 0 ft. high by about 8 ft. diameter. The current f hot gas completely carbonised the coal being dded to this chamber. The smokeless fuel was rawn out at the bottom through a water seal. n this plant there was no difficulty in carbonising niformly one ton of coal per hour. The gas made both chambers, after cooling and scrubbing, as available for gas engine running or boiler ring. When smokeless fuel was not desired he fuel could be burned to ash in both chambers, nd gave practically the same yield of power gas s an ordinary producer, but the quantity and uality of the oil recovered were much enhanced.

Mr J. G. Roberts said that in the pottery trade e did not think there was a plant in existence using as firing which had been an unqualified success. he two biggest plants that he knew of had been bandoned. For pottery firing a long and inensely hot flame was needed, and good coal was equired to get that flame. The regenerative ystem of heating had not been profitably applied o the heating of pottery and the expense of epairs became very great.

Mr. W. F. Reid said that he thought the proibition of the use of solid fuel was quite impracticble at present. Public opinion was not yet ripe or that. They must first try to educate public pinion to the great evils and probably the injury o health due to the consumption of coal. A great leal had been done in reducing the amount of moke from coal. As a member of the Council of the Coal Smoke Prevention Association, he said hat they were quite satisfied with the progress hat had been made in London and other large ities—especially with regard to the elimination of fogs in London. The use of more gas had had some influence, but so also had the expression of public opinion and in a few cases the action taken by local authorities. Dr. Haldane had recently pronounced the opinion that the particles of carbon contained in smoke were distinctly benefiial to the lungs of those who breathed them, and he was now endeavouring to prove that it was beneficial to inhale particles of carbon to prevent tuberculosis. His own belief was that it was the tarry substances that were so injurious.

Mr. W. F. Cooper expressed the opinion that the trouble really was that there was no one in Parliament who really understood the subject.

Dr. J. T. Dunn said that some progress would be achieved if consumers as a body could be persuaded that it would pay them to buy coal on a calorific basis. Good coal was high in price, but with ordinary inferior coals, the price diminished very rapidly, so that it did not pay to sell the latter. That was the reason why those coals were not in many instances worked. Sale on a calorific basis would, he thought, enable colliery owners to work those at present unworked portions of the seams with greater prospects of getting some remunerative price. There were many advantages in low temperature carbonisation processes, but it was not possible to have all the advantages at once. In the ordinary process of gasworks, a very small proportion of the nitrogen was recovered, but low temperature processes, where the solid fuel produced was burnt directly, as in domestic grates, recovered a smaller proportion still. If, however, the solid fuel was consumed in a low temperature gas producer, a greatly increased yield of ammonia could be obtained.

Mr. W. J. Rees agreed that the purchase or sale of coal on a calorific basis would be advantageous. He did not think it was the purchaser but the colliery proprietor who stood in the way in that connection. If such a scheme could be brought into operation successfully, it would be to the mutual benefit both of the colliery owner and the user of the coal.

The President remarked that the origin of Dr. Haldane's experiments was that he had found that miners as a class were particularly free from tuberculosis, and, having regard to the dusty conditions in which they were working, he was led to believe it might be due to the coal dust. The fog question was more important still. The fog caused the rise in mortality, and the discomfort, and he thought that most of the troubles arising from the imperfect combustion of coal were not due to "smuts," but to the products of distillation.

Professor Armstrong in reply, said that he wished to make it clear to this Society that it had a mission which it could fulfil. There was now a golden opportunity for it to take up this subject and make it their own. They should be put in a position to approach Parliament on the subject and urge our views upon them. The whole subject must be dealt with from a practical point of view and proved by results. Great credit was due to a man like Mr. Elwell Parker for conceiving the idea and spending so much time in experiments on a subject of which he knew nothing—that was the type of man who started things in this country; but some concerted effort should now be made to work the problems out. They could be worked out in a very few years, he was sure. The original coalite process was a low temperature process conducted in such a way that the products were carried off immediately, and there was practically no benzene or toluene in the tar but a good deal of carbolic acid of much higher quality than was produced in any other way. The real source of benzene in those processes was not the tar but the gas. The gas produced was very rich and if stripped it gave a satisfactory amount of benzene, leaving gas of a high calorific value which needed dilution to be used for ordinary steam-raising purposes. He now felt highly confident that the work had been taken in hand in such a way that there was every prospect of good results being attained. His own view was that the gas industry ought to take the matter very seriously into consideration.

RECENT IMPROVEMENTS IN BY-PRODUCT COKE OVEN PRACTICE.

BY G. P. LISHMAN, D.SC., F.I.C.

It must be said at once that since the introduction of the direct processes there has been no great change in coke works practice in this country.

The high wages paid in coke works have led to numerous labour saving devices, and it is largely with items of this kind that the present notes are concerned. Most of these appliances have been

in use in odd places for some years. What may be regarded as "recent," however, is the general adoption of a number of them in conjunction with each other on recent plants.

Size of ovens.—The most important advance on these lines is undoubtedly the increasing size of ovens, and this involves some special problems which will have to be faced by all makers. Since with a larger oven any given output of coke can be obtained in fewer operations increased efficiency certainly lies in this direction. In America 16-ton ovens have been built by the Solvay Co. for some time. These ovens are built of a silica brick and are run at a very high temperature, coking in 16 hours. I have no particulars as to the life of them, but with such an output the cost of re-building can very soon be made up. The largest oven working in England to-day is the Collin at Middlesbrough. These are 3·1 × 0·5 × 11 metres. The 72 ovens make 3000 tons of coke per week. The Solvay Co. have also completed a battery of 12-ton ovens in England, and the Simon-Carvès Co. have a battery of 11-ton ovens ready to start. These large ovens, besides being cheaper to work, involve less capital outlay, and the quantity of inferior coke on tops or ends is proportionately reduced. I am informed that in Germany an oven 3·5 metres high is now working.

Charging apparatus.—Where it is not necessary to compress coal most of the constructional firms are adopting levelling machines and the electrically driven coal loading car. This is a machine consisting of a steel under-frame carrying four hoppers which contain one full oven charge. It runs along the oven tops on rails in charge of one man, and by its means the whole laborious process of tub-pushing, which requires a number of men, is dispensed with. The only drawback to it is that it means the collecting main being on one edge of the battery.

Coke handling.—There is now commonly some mechanical arrangement for this purpose. The chief varieties are :—

(1) The inclined car discharging into elevated screens fixed or shaking. This is probably the cheapest way to load coke, but it is sometimes difficult to arrange for storage.

(2) The inclined bench and coke conveyor. It is usually a tray conveyor which rises up an incline at the end of the battery and delivers to the screens. Coke conveyors are improving and are becoming more popular than formerly.

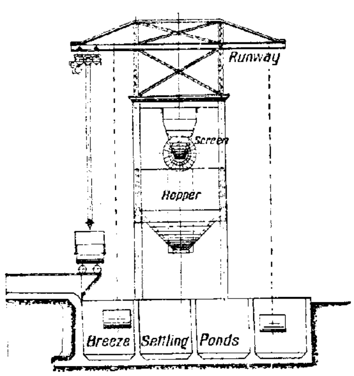
(3) The Goodall Quenching Car, though not common, has been repeated several times. This consists essentially of a revolving table into which the coke is discharged from the oven an quenched by a series of sprays fixed over th table, and also by sprays in the quenching hoo which is part of the car, and through which th coke passes on its way to the table. Whe quenching is complete the coke is discharged ove shaking screens into railway wagons. The ballas and breeze are caught in special hoppers als forming part of the car, and the mixture is emptie at intervals into separate trucks. A useful plan for handling breeze which is carried down by th quenching water has been put up by Simon Carvès Ltd. at one of their recent plants. Thi consists as shown in the sketch of a small telphe which elevates special bogies into which th breeze is filled by hand and carries it to a revolvin screen. On arriving at the screen the coke i automatically tipped and the coke passes throug the screen where it is separated into three sizes.

(4) The enclosed type of car as used at Vienn Gas Works (Koppers Gas Oven) has not yet bee seen in this country. This is an enclosed chambe running on rails, carrying its own motor and pum The water is used over and over again, the pum drawing it through an eight-inch flexible suctio pipe from a trough running along the batter under the car.

The adaptation of ovens to the supply of lighting gas has been extended, but so far not nearly sufficiently. The heating of ovens by producer or blast furnace gas can be done quite satisfactorily, and yet most of our plants consume their own high-grade gas, many of them taking the whole of it. Regenerative plants are still a small minority in this country, the value of gas as a by-product not being even yet fully recognised.

Economy has been effected in many plants by means of door-lifting winches attached to the rams and coke quenchers, so that raising and lowering of doors is carried out mechanically. In this country they are always worked from the ram motor, but American practice condemns this and works them from an independent motor. It is certainly undesirable to multiply clutches. This improvement has been more or less forced on us by the increasing size and weight of doors required for the newer and larger ovens. The Collin plant at Middlesbrough has a very nice arrangement on the hearth side, the travel of the quenching hood and the lifting of the doors being done by a special electrically driven machine operated from the hearth level.

Mechanical ascension-pipe cleaners have been introduced lately with some success, and also the split ascension-pipe. The latter is in use at Consett. The pipe is made in two halves longi-



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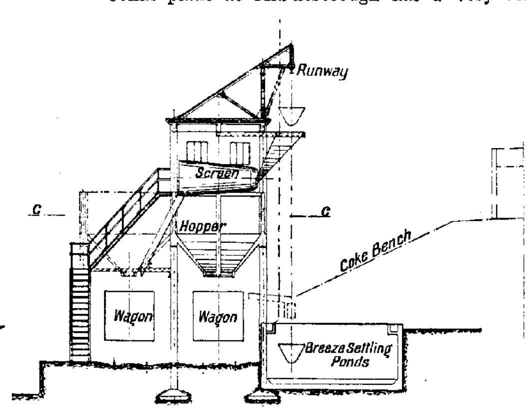

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dinally, the halves being held together by bolts ssing through lugs. Hinges and pins may be ed on one side with advantage. The faces of urse have to be machined, but a narrow fillet enough for the joint. When the two sides are parated a pipe which might otherwise take all y to clean is done in a few minutes.

High-speed turbo-exhausters are now very mmon in new plants, though the Otto Company s reverted to the drum type, placing it before the nzol scrubbers, and leaving most of the plant der suction.

With regard to by-product plant it cannot said that there is any really important improvent to record for the last few years. The direct ocess has come to stay and the different varieties too well known to be described here. There two similar semi-direct processes, however, ich have just started working in England. ese two processes are both working successfully aking excellent salt and an account must be en of them, not because they are better than ers, but because they are newer. They are th modified Mont-Cenis processes, one run by Semet Solvay Co. (Marr's patent), the other the Collin Co. The great point in connection h all direct and semi-direct processes is to oid making too much mother liquor and it is the schemes to this end that the various designs fer. In the Solvay process benzol is extracted m the gas before the ammonia. In this way re-cooling of the gas after the saturator is oided. Whatever the drawbacks of such a ocess may be, and none appear to have shown emselves yet, it is certainly a saving both in pital expenditure and in cooling-water. After ving the benzol scrubbers at —25° C. the is led to the saturator, receiving on its way monia-steam from the still which deals with the ndensed liquor. The steam on coming into ntact with the gas is suddenly cooled down to equilibrium temperature of about 45° C. and amount of water-fog is formed which if carried to the saturator would by diluting the bath d to prevent the crystallisation of salt and oduce too much mother liquor. This water is therefore extracted from the gas by passing hrough a special separator which is understood be of the nature of a Pelouze tar-extractor. is apparatus drains back into the still and the ses saturated with water, but no longer superurated, pass forward to the acid bath. Owing o the heat liberated in the reaction the gas emperature at the bath outlet is 55°—60° C. he gas is still saturated and when it is considered hat each cubic metre raised 10° C. will carry way 63 grams of additional water it is obvious hat there is no fear of excess mother liquor. In ractice water is added to the bath all the time. he liquor feeding the still is preheated in a heat xchanger by waste liquor coming from the still.

In the Collin process the benzol scrubbers ome after the saturators which involves re-cooling f the gas. The method of drying the gases coming om the still is also different. The vapour from he still can join the gas by either of two pipes and he amount passing each way can be regulated. ne of the pipes leads straight to the gas main hile on the other is a liquor heater which serves to ry the ammonia-steam. This is simply a ubular heater of different form altogether from he original Mont-Cenis heater and dryer. In this ay the ammonia-steam is prevented from superaturating the gas with water and the water fog hich is extracted in Marr's process is in this case revented from forming. The gas temperatures re practically identical in the two processes and n each the rock-salt difficulty has been found and vercome. Hot water everywhere is the cure and he process admits of considerable quantities being used. Also it is well to have a lead steam pipe in the saturator and give it a boil up once a week. In addition the acid should be run in up to 18%, worked down to 8 or 9% then made up again. Continuous working at one acid strength is apt to lead to rock-salt.

In connection with the direct process one of the problems which presents itself where benzol is recovered is the removal of naphthalene during the cooling of the gas. After the saturator direct process gas, though perfectly free from tar, contains anything from 10 to 20 grams of naphthalene per cubic metre. Its temperature is about 80° C. It can be cooled down to 55 in tubular coolers in the ordinary way, but coolers after that rapidly become blocked with naphthalene. Three methods are used for overcoming this: (1) Duplicate plant up to the benzol scrubbers, one part being steamed out while the other is in use. It is desirable to duplicate even the gas main to the scrubbers and to keep it as short as possible and give it plenty of size as it is always liable to block.

(2) The Otto method of direct cooling in a tower by contact water sprays. The quantity of water required is very considerable, but where this is available the contact method is the simplest and best. The naphthalene is washed down in granular form and may be skimmed off the water as it flows through troughs.

(3) Simon Carves, Ltd. have patented a process which consists in spraying the gases with creosote oil which dissolves the naphthalene and the oil when saturated is pumped into crystallising pans from which the liquid oil is subsequently run off and used again. The circulating oil naturally mixes with the condensings from the gas and the complete and continuous separation of the oil and water in special tanks is part of the process. In warm weather the naphthalene does not separate very well, but the process is quite effective.

For the rest our recent changes are but small matters and may be summed up very shortly.

Ammonium chloride. Where the coal contains sodium chloride a good deal of the ammonia can be recovered as ammonium chloride: sometimes 30% of the salt made can be got as chloride. The direct process lends itself well to the recovery of ammonia in this form as in the washing of the gases with hot liquor the chloride is extracted. A saturated solution is obtained which is evaporated to obtain a crude salt. The salt, a fair colour at first, soon turns black. It has been found that if the dark salt is heated for some time to a temperature just short of volatilization and redissolved in water, the carbonaceous matter is rendered insoluble and after settling and filtering a clear liquid is obtained from which a permanently white salt is produced by evaporation. This method has also been patented by Simon Carvès, Ltd., but I hear there is now another process in which the same result is produced in one evaporation.

Naphthalene.

Mr. Middleton, of Consett, has rigged up a useful little subliming plant, a short description of which may interest some who have stocks of dirty naphthalene. It consists simply of two old Lancashire boiler tubes, 3′ diam. A bridge is built in the usual position, and a few coils of steam pipe laid in the furnace area serve to volatilise the naphthalene which sublimes over into the rest of the tube and nearly fills it up. A small outlet is left at the other end for observation. After first sublimation the naphthalene is slightly yellow, but on re-subliming a pure white product is obtained. No live steam is used.

The number of by-products manufactured at coke works is being extended. Carbolic and cresylic

acids and pure naphthalene are made at one plant in Durham. Pure benzene and pure toluene are made at certain places, but most coke works refineries go no further than "Government benzol" and toluol containing 75% toluene. More pure products ought to be manufactured. Pyridine is still wasted on all coke works. Also cyanogen.

Briquettes.

The making of coke ballast into briquettes is a useful line, plant for which is to be started at Crook, Durham. 7% of pitch and 3% tar are to be used.

Pitch coking.

This has been tried at several plants with varying success. Some have used 7 or 8% of pitch and taken no harm, while others find the ovens stick if only 2 or 3% is used. Evidently one should proceed cautiously in this matter when experimenting, the result appears to depend on the nature of the coal.

Dry cleaning.

Another interesting point is the "dry cleaner" in use at New Brancepeth. It is found that dry coal when crushed in an ordinary bar type disintegrator may be divided into two qualities by means of a riddle. The crushed coal is passed through a screen with $\frac{3}{16}''$ holes. Coal passing through will contain 6% ash while the coarser part contains 30 or 40%. This is returned to the washer.

Lampblack.

This is made from surplus gas at a certain plant, but the exact method is kept a fairly close secret. It is understood that a number of gas jets burn under a revolving plate, and the deposited carbon is scraped off.

The time allowed for the preparation of this paper has been very short, and much has been omitted. It must be confessed that progress on the chemical side is very scanty, and this is not surprising, seeing that the industry has no research laboratory in the whole country. It is unlikely that we can go on making the same products indefinitely. Already we waste several substances; there are others which might be made if it could be done cheaply enough. In the past we have depended on Germany for our progress, and it is up to the owners of coke ovens to see we do not have to do so in future.

I am very much indebted to numerous friends, who have sent in particulars and suggestions for these notes.

DISCUSSION.

The PRESIDENT explained that owing to the difficulty of export large quantities of pitch were lying in the yards of the various tar distillers. Some relief was being obtained by mixing it with the coal and re-distilling it. The ash of coke produced from the carbonising of pitch was very low indeed, so much so that the clinkering and attention that the fires required were very much reduced.

Mr. G. S. COOPER mentioned that the Ebbw Vale Company had one hundred 11-ton ovens using a quick burning coal and for some time had produced from 5000 to 6000 tons of coke per week. The adaptation of ovens to the supply of lighting gas had not developed to a very large extent in this country. There were only two places of any importance using coke ovens for making lighting gas. In Middlesbrough the scheme had been a very great success; they were able to keep the price of gas at pre-war level, and also to make a very considerable profit. The other instance was Leeds. An enormous amount of gas had been wasted in the past in coke-oven plant; if the gas were used in gas engines it would give probably two or three times as much power as by using it under steam boilers. In Germany particularly there had been a good deal of co-operation between the iron and steel industries and the coal industries, and it was owing to that co-operation that they were able to carry on certain sections of their work at such high profits. At the Birmingham Corporation Gas Works a battery of coke ovens was used to supply the town gas, and the ovens were heated by means of gas made in Mond producers. Dr. Lishman had said with regard to the Otto Company that high speed turbo-exhausters were now very common in new plants, although the Otto Company had reverted to the drum type, placing it before the benzol scrubbers, and leaving most of the plant under suction. The general practice was to work the plant under pressure, and he had heard of two instances lately where there had been serious explosions in plant worked on suction. One of the advantages of the direct recovery process was the economy of heating, and the original semi-direct process on which all others were more or less based had one point which had not been adopted in other processes—the gas was first cooled and then heated again. That gave an unsaturated gas, permitting the free use of water to get over the rock salt difficulty. The naphthalene trouble was also at once eliminated.

Mr. H. L. TERRY asked whether the lampblack was equal in its general physical characteristics to the lampblack that came from the United States.

Dr. LISHMAN replied that most of the new plants were working under suction without any trouble. The advantage of working under suction was that it was possible to use the slow speed exhauster, which required less power.

In reply to a question, the PRESIDENT said it was difficult to say why gas from by-product ovens was not more largely used in the gas world. It probably arose from the fact that the large producers of gas were not in close proximity to those using coke. It had been proposed to get over that by piping the gas, but there were difficulties in that connection that had not so far been overcome. The gas supply in Middlesbrough was in the hands of the Corporation, and they had entered into a contract with large producers of gas in the coke ovens in the neighbourhood. The scheme had been extremely successful. In Germany several groups of towns in the neighbourhood of coke ovens were supplied with gas from them. The difficulty here was that the large producers of furnace coke were not sufficiently near the towns to make the process attractive, but there was also the other more or less technical difficulty that arose in the case of Middlesbrough, namely, that they were under an obligation to maintain a continuous supply of gas throughout the whole town, while they had taken upon themselves the responsibility of transferring that responsibility to a private firm, the firm owning the coke ovens. But in that case they relied on the fact that they had a water-gas plant which they could bring into use fairly rapidly.

WASTE IN COAL PRODUCTION.

BY HENRY LOUIS.

At a time when the subject of fuel economy is being brought so prominently before our notice, it is important to have before our eyes a complete review of each and every operation connected with coal in which waste occurs, and in which therefore the introduction of more economical methods is at any rate possible. The waste and losses connected directly with the getting of coal are by no means the least of the various forms of

loss, and I propose in the present paper to lay before you a brief account of some of the principal forms in which such waste occurs. A clear conception of the nature of such losses is obviously the first step towards their avoidance.

The coal output for 1913 is given by the Home Office as nearly 287½ millions of tons, and it is important to note in the first instance how much of this total output is actually available for use by the nation at large, and in the second place how much other coal has been sacrificed in order to obtain this output. Put in somewhat different words, the first named portion of the investigation refers essentially to the saving that could be effected above ground in dealing with the coal after it had been brought to bank, and the latter to the saving that might be effected in the underground operations of the colliery.

From the total output of coal there is first of all to be deducted the coal used in what is generally spoken of as colliery consumption. Obviously a certain proportion of the coal raised in the country is consumed in raising it; in some districts, some or all of the colliers are supplied with free coal, which is sometimes included under the head of colliery consumption. This is however not a correct way of looking at the matter, because the coal thus supplied to the men should be looked upon as being a portion of their wages paid in kind instead of in cash, and hence this coal is sold or given in place of money, and should not be included in colliery consumption properly so-called. The only objection to the practice of giving free coal, at any rate from the standpoint of the present discussion, is that such coal is apt to be, and as a rule is used very wastefully, and that if the men had to buy the coal and pay for it, more economy would be observed, and a considerably smaller quantity of coal be made to answer the purpose.

Colliery consumption properly speaking should be restricted to mean the coal used in generating the power necessary to work the colliery. It would not be difficult to arrive at the amount thus consumed; all well managed collieries keep a careful record of their own consumption, and in some districts attempts have been made to obtain approximate statistics for the entire district. It would however need a proper inquiry backed by due authority to obtain figures for the country as a whole, because it is precisely those collieries where the consumption is greatest that will be the least willing to supply such figures. A certain amount of difficulty may arise from the fact that the coal thus used is of inferior quality, and not infrequently unsaleable. Within late years efforts to use inferior coal have been multiplied, and in many cases have been attended with marked success; I know cases where the whole of the power required to work a colliery is now being obtained from material which a few years ago was thrown on to the waste tip, and the use of inferior coal in gas producers is contributing to the extended employment of such material. There is still, however, too great a tendency amongst colliery managers to consider that if power is generated from an unsaleable material, there is but little need to exercise economy in its consumption. Such a view is one that should not be allowed to obtain, and it has only arisen owing to the fact that the calorific value of the fuel consumed is too often disregarded and its money value alone is taken into account. It naturally happens that many collieries are so situated that they necessarily produce a certain amount of impure and dirty coal, the money value of which is less than the cost of marketing it, and the assumption is often made that such coal is therefore worthless; that it has however a very definite value as a fuel is shewn only too conclusively and too unpleasantly by the burning pit heaps that may be seen in any colliery district. Definite information as to the quantity of coal burnt for colliery consumption is not obtainable, and a very rough guess is all that is possible at present. From my own observations I am inclined to think that the colliery consumption of the country is somewhat of the order of 7% of the output, or say about 20 millions of tons. It is evident that if groups of collieries would combine to erect central gas producer plants, using low-grade coals, from which power could be distributed to the various pits within a reasonable radius, the saving that could be effected both by the utilisation of the by-products and by the substitution of inferior for better-class coal in the generation of power, would amount to a very large annual sum.

In many districts vast quantities of fine coal dust accumulate in the screening plants and lie there until periodically, when the nuisance becomes too great, they are cleaned out and the dust thrown away. I have been in colliery heapsteads in South Wales where the dust was literally ankle deep. Such coal dust is in many cases quite fine enough to be used direct for firing boilers or furnaces, and is well adapted for this purpose; it could be readily and cheaply cleaned and graded by the use of some form of pneumatic dressing machinery, such as has been erected in several of the Westphalian Collieries. Nothing of the kind has been attempted, as far as I know, in this country, and this valuable article continues to be thrown away. Here again is a source of economy which in some parts of the country would be decidedly important.

Turning next to the underground operations, the waste of coal in the pit may be considered under two heads, namely more or less accidental and more or less deliberate. It is practically impossible to win the whole of the coal in any seam; some is always lost, owing to the waste in undercutting, the crushing of ends and of odd portions of pillars, and the leaving of barriers and shaft pillars. The intention is always that a shaft pillar shall be robbed when the rest of the pit has been worked out, but it frequently happens that by the time that the latter occurs, much of the coal in the shaft pillar is so crushed that it cannot be won. As regards barriers they are in part left deliberately, whilst in other cases the intention is ultimately to win them as far as possible, though here again this cannot always be accomplished. The waste in undercutting is being gradually decreased by the use of coal-cutting machines instead of undercutting by hand, owing to the fact that the machine makes a much narrower cut than is possible with the pick, and is often able to undercut in clay, where the hewer would have to cut in coal. More might no doubt be done in the substitution of machines for hand-labour, but the subject is a difficult and a complex one, and I do not intend to suggest that the indiscriminate use of coal-cutting machines is in all cases to be recommended. Nevertheless it ought not to be forgotten that our coal reserves are a national asset, and that the interests of the nation at large should receive some consideration as well as the immediate profit that the colliery owners draw from their operations.

The crushing and loss of some portions of the seam are almost inevitable on any system of working; such loss is no doubt less when the coal is worked by longwall than by bord-and-pillar, but here again the best system of working any given seam does not depend upon this consideration alone, though I would urge that the national aspect is too often entirely neglected. Upon the whole there is no doubt that the use of the longwall method is extending, and that loss

in working is decidedly less than it was, say 50 years ago, and there is every reason to hope that still further improvements in this respect may be looked for. Improved methods of stowage, such as the well known hydraulic methods, may also be helpful in this matter. An important fact to be borne in mind is that a colliery is after all not a philanthropic institution, and that no colliery manager is going to extract small remnants of coal pillars when the cost of doing so is greater than the cash value of the coal, and further that his costs depend largely upon the prices of pit timber, because the removal of such small portions of coal is rarely possible except by the lavish use of pit-props. That the price of these has risen lately to formidable figures is well known, the main reason being that for many years afforestation has been wholly neglected in this country. What little has been done has been due to the enterprise of a few individuals, and it is impossible to acquit of blame in this respect some semi-public bodies, such as the Ecclesiastical Commissioners, who hold vast areas of land. They prefer to get the maximum immediate revenue out of their lands, say by letting them as grouse moors, instead of contenting themselves with a lower immediate return, and planting timber, which would in the course of time not only yield a handsome income for themselves, but prove an important advantage to the industries of the nation. The need for cheap timber if the maximum output is to be obtained from a given area of coal may not at first sight be very obvious, but there is nevertheless a very close connection between them. As regards the leaving of barriers between adjoining properties, this has in the past been a very serious source of loss, and is still to-day, though it is to some extent decreasing owing to the growing tendency of colliery companies to amalgamate, and for large companies to absorb smaller ones, so that ever larger areas are being controlled by one interest; even so there is room for much improvement, and possibly legislation on the subject might not be altogether out of place. I hold the view that although coal in this country belongs rightfully to individuals, it constitutes as a whole a national asset, and the nation is entitled to protect itself against undue waste. As to the proportion of coal that is left in the ground, here again nothing more than a very rough guess is possible. I estimate the proportion as something of the order of 5% of the coal existing in the seams, so that the total quantity is formidable enough. It may be as well to point out that the coal thus left in the ground, cannot be, as has sometimes been asserted, looked upon as a reserve that future generations may be glad to utilise. On the contrary, coal thus left behind cannot be won afterwards, and must be looked upon as irretrievably lost to the country.

A source of loss that may properly be referred to at this point is that due to "gob-fires," that is fires underground originating in the spontaneous ignition of small coal left behind in the worked out portions or goaf of the coal seams; such fires often spread to the coal seam proper, and large areas of coal have thus at times been lost. The question of the best means of preventing such gob-fires is now attracting much attention, and excellent work upon it has been done within the last few years in the Research Laboratory of the Doncaster Coal-Owners. It has been attacked mainly from the standpoint of the chemist, the object being in the first instance to find out what are the causes and conditions that favour the spontaneous ignition of coal, and in this way to arrive at the proper remedy to be applied. There are good grounds for saying that the theory of the subject is beginning to be well understood, and that the colliery manager ought, in the light of the scientific information thus given, to be able to keep losses of coal due to gob-fires within very narrow limits in the near future.

In addition to coal thus accidentally left behind in the pit, there are many cases in which coal is deliberately left behind or thrown back into the goaf.

In many parts of the country where non-coking coal is produced all small coal is left underground on the plea that it would cost more to bring it out than it would fetch in the market. This coal is not mere dust, for in many cases nut coal is sacrificed in this way; in parts of Nottinghamshire I have seen coal loaded underground with a fork with 1½ inch tines, all coal under 1½ inch being thus thrown away. It need hardly be said that this coal was quite as good from the point of view of heat production as the coal that was sent up the shaft and much of it could have been used at once for firing boilers. How much coal is lost in this way it is difficult to say, but these are cases where the coal thus wasted amounts to over 20% of the output. The same is also true of many parts of South Wales.

Again there are many cases where only the better portions of the seams are being won, the rest of the coal being left behind and lost, simply because it is of somewhat inferior quality, though it is as a matter of fact quite capable of being utilised. Take for example a statement from the Mines Report of 1910, referring to the Barnsley Seam, worked at a number of mines in the Doncaster district:—"at several of these mines nearly one-half of this fine seam is left unworked, the 'top-softs,' about 4 feet thick, being left to fall in the goaf. This part of the seam is not of such high quality as the better portion, and that is the chief reason for it being left unworked. . . . To lose practically 40% of this seam is also a national loss." A number of analyses of the Barnsley Hard and of the Barnsley Softs from the Doncaster district have recently been published in some of the papers issued by the Doncaster Coal-Owners Laboratory, and these show practically no difference in chemical composition. It is quite certain that as regards calorific value there cannot be any serious difference between the two classes of coal.

In the Barnsley district proper, a certain thickness of the seam, sometimes amounting here to more than 40% of the whole, the "Top-Softs" and the "Bags" as the upper portion is locally called, is very generally left behind in the goaf. Apart from its softness, it is a good coal; a sample recently tested in my laboratory gave a calorific power of 13,400 B.T.U. and 3·8% of ash.

In Fifeshire the Great Seam 6 feet to 8 feet thick consists of about 2 feet of Ironstone, about as much common coal, and then about 3 feet of Cannel or Parrot coal. The latter alone is worked, all the rest of this fine seam being left behind in the goaf.

In Lanarkshire the Ell Coal, about 6 feet in thickness, is worked, and the Head Coal, about 2 feet in thickness, left behind in the goaf.

These few examples, taken somewhat at random, will serve to exemplify the nature of the loss of coal that is here discussed; in most cases the coal thus left behind must be looked upon as totally lost; in others it may be in part recovered. Thus some of the areas in Lanarkshire above referred to are now being worked over again, with the object of recovering as much as possible of the Head Coal previously rejected, but obviously such an operation can never be a very satisfactory one. In many districts where there is one particularly good or especially valuable seam, this is often worked out before any other seams are touched, without regard to the fact that such working damages other seams less valuable

to-day, but nevertheless containing coal of quite good quality. The result of this damage is that a certain proportion, or possibly in some cases the whole of these other seams is rendered unworkable, and great loss of coal is thus brought about.

It is practically impossible to present any figures shewing the amount of coal lost to the nation as the result of this deliberate waste, but it certainly amounts to enormous quantities in the aggregate. It is not easy to suggest any remedy for this loss; some authorities favour legislation, and the imposition of heavy taxes upon coal left behind has been suggested. This can hardly be looked upon as a scientific solution of the problem, and undoubtedly a better remedy would be the invention or the elaboration of methods of utilising these inferior coals, which would give them a value sufficient to make it worth the while of colliery proprietors to work the whole of their coal. Some of these difficulties are unquestionably connected with our systems of mineral ownership, under which two seams within the same area may be let to different people, each of whom works for his own interests alone regardless of the interests of the neighbour above or below him. The importance of the question is very great and it undoubtedly deserves the fullest possible investigation from every standpoint, there being probably no portion of the entire subject of coal economy that promises more valuable results.

I wish to state definitely that the all important question of safety is in no wise involved in the considerations here submitted, or rather that the reform of most of the sources of waste that I have indicated must result in increased safety for the coal miner. The diminution of gob-fires is obviously a case in point. Again, if it were possible to turn to good account the accumulations of fine coal dust, which constitutes such a grave danger in most of our collieries owing to the disastrous explosions to which it may give rise, the removal of this dust from the workings might readily become a source of profit instead of a loss as at present. It need hardly be said that such coal dust could, as has already been pointed out, be employed directly for firing, and that its cleaning and subsequent utilisation should present no insoluble difficulties. The coal left behind in the goaf is naturally also a source of danger to the coal miner, and in this way again the successful utilisation of inferior coal would contribute to the safety of our collieries. The subject of safety is one of such supreme importance, that I have thought it advisable to refer specially to the fact that decrease in the present waste of coal would mean, if anything, a corresponding diminution of the risks to which the coal miner is exposed.

My object in submitting this paper has been to bring before the Society some information as to the nature and magnitude of the losses involved in the getting of coal as an integral portion of the investigation of the problem of fuel economy, and incidentally to point out that although these are essentially problems for the mining engineer, yet it is highly probable that the assistance of the chemist will have to be invoked before their complete solution is arrived at.

In conclusion, I should like to direct attention to an admirable address delivered in the beginning of this year before the Second Pan-American Scientific Congress at Washington by George Otis Smith, Director of the United States Geological Survey, upon "The Public Interest in Mineral Resources," a sentence from which aptly summarises my views on this subject:—"The Governmental duty to the mining industry first of all is to promote use without waste." This is exactly what we ought all to aim at.

Discussion.

The President said that Professor Louis had given a very vivid bird's eye view of what was happening in the collieries more or less throughout the country. The magnitude of the losses that were going on in one direction only—that is in the amount of fuel used by the collieries—showed how fundamentally important the coal question was, and that it was one to which a Society concerned in chemical industry should give attention.

Professor Armstrong asked if there was not a great waste of pit props owing to the fact that no precautions were taken to prevent decay.

The President then quoted from a letter which had been received from Mr. Wallace Thorneycroft, as follows:—

"Professor Louis inadvertently refers to the great seam as being in Fifeshire, whereas it is one of the East Lothian seams which has been worked for over 500 years. Unfortunately the Lanarkshire Ell Coal is rapidly approaching exhaustion. If there was any virgin area of this seam 6 feet thick, I do not think there would be very much left below ground nowadays.

"Twenty years ago the East of Scotland was a great offender with regard to small coal left below-ground, but now there are very few collieries at which it is not all brought to the surface, washed, sized, and sold as nuts, peas, etc., leaving only the gum—that is all that passes through about ¼ in. mesh, to be burned at the collieries for steam raising purposes. By this system the small coal is put upon the market and its calorific value made available in a very convenient form, probably the best possible.

"I do not think there is any district where this system is not applicable, and if that be so, I do not quite agree with Professor Louis that a large sum annually could be saved if groups of collieries combined together to erect by-product gas producer plants from which the power produced would be distributed. The gas producer capable of dealing with this wet gum has yet to be designed. It has often been tried, so far without success, and this is one of the points of contact where the mining engineer welcomes the assistance of the technical chemist.

"There are many other points of contact between the two professions; Professor Louis has referred to some of them, and any one wishing to pursue the subject further should refer to the Report of the Royal Commission on Coal Supplies published in 1905 (Cd. 2353, price 4d.), and also to the detail evidence given by the best men of the time (1901—1905) on each subject. A study of the subject will, I think, reveal the fact that it is the consumer of the coal rather than the producer who is the more wasteful.

"Professor Louis says that the calorific value of unsaleable fuel is too often disregarded, and this to some extent is the case, but I do not think the mining engineer can be blamed for not spending capital to reduce the consumption of fuel he cannot sell. If, however, he has a surplus of such fuel and the technical chemist can evolve a process by which by-products can be extracted from such fuel of sufficient value to warrant the necessary capital expenditure, and supply sufficient power to work the colliery, then a true economy would result, although the consumption of fuel for colliery purposes would probably be increased.

"This point seems to raise the important question of what is really meant by fuel economy. The ultimate success or failure of any process must always depend upon whether or not it will pay, and not whether so many tons less fuel are used.

"It is true that our coal reserves are a national asset, and it is equally true that a colliery, or for

the matter of that any industrial concern, is not a philanthropic institution, and if such concerns were run on principles economically unsound the effect on the interests of the nation at large would be very quickly disastrous.

"True scientific investigation let us have to the full, including inquiry into whether any known process has not been adopted by the industrial world, and if not, why not, but I think that a word of warning is not out of place lest we rush headlong into enterprise that is economically unsound.

"Professor Louis touched in passing on the benefits gained in one branch of his subject by amalgamation of small concerns. I venture to suggest that it is in the national interest to encourage the tendency to amalgamate in all branches of industry. More large concerns with interests spread over wide areas would hasten the adoption by the industrial world of ideas evolved by the scientific world."

A Member asked whether the nationalisation of railways, resulting in lower rates, would not aid in the working of low class material.

Mr. W. F. Reid said that on account of the war pit props had become difficult to obtain, and it seemed quite impossible for us to produce sufficient for our own needs. He asked for information with regard to the utilisation of other material than timber for pit props. He believed that concrete had been used.

The President said that the use of concrete as pit props had always struck him as introducing a very interesting problem, because concrete took the place of timber in many respects.

Professor Louis, in reply, said that Professor Armstrong was perfectly right in saying that pit props had been wasted. But they were not being wasted to-day; they were much too precious. For a long time pit props had been delivered in this country at a very low price, and the result had been wastefulness. The price had been trebled since the war began, and people had been forced to economise. He was afraid it was hopeless to expect to be able to use re-inforced concrete instead of timber. The pit prop made of wood gave way gradually, and it gave some warning; but when concrete failed, it went all at once, without warning. In addition to that, it was awkward to set, and was inelastic. The problem was a most difficult one, a very curious combination of elasticity and rigidity being required. He believed it would be possible to produce a steel prop that might take the place of wood, and such props had been used. He was pleased that Mr. Thorneycroft, one of the leading authorities on coal mining in Scotland, agreed generally with the views that he had put forward. He agreed that the amalgamation of smaller concerns into larger ones was bound to be beneficial to the interests of the nation at large. From his experience of other countries, he was utterly opposed to any idea of nationalisation either of railways or of mines as a means of saving money. Few people who had had experience of Government Departments recently would think that Government administration ever led to economy. In Germany, in a district where the collieries were practically all nationally owned, the system had proved a failure from an economic standpoint. Wages were lower there and costs higher than in the privately owned collieries in Germany. He was convinced that the nationalisation of railways could never lead to economy in any way.

THE SHALE OIL INDUSTRY.

BY D. R. STEUART.

Oil shale, the foundation material of the manufacture, is mined in much the same manner as coal. The principal marketable products are shale spirit, lamp oils, internal combustion engine oils, fuel oils for the Navy, oils for gasmaking and gas-enriching, lubricating oils, solid paraffin, still coke, and sulphate of ammonia.

There are now four refining companies, Young's, Oakbank, Broxburn, and Pumpherston, with a total capital of about £3,000,000. The men employed are 10,000, including miners. Besides these there is a private company at Philpstoun (Ross & Co.), making crude oil and ammonia.

The works now existing all lie in one shale-field situated in West and Mid Lothian. The centre of the field lies some 12 miles west of Edinburgh. It stretches from the Frith of Forth at Hopetoun southwards for 16 miles, with a width varying from three to eight miles or so.

The shale measures are situated geologically in the Calciferous Sandstone series and lie under the Carboniferous Limestone and above the Old Red Sandstone. About a dozen different seams have been worked in the Upper Division of the Calciferous Sandtsone series, which is some 3,000 feet in thickness. The shales worked are often five to six feet thick.

Paraffin oil manufacture started in Scotland in 1850 at Bathgate to work the Boghead or Torbanehill mineral, which yielded 90 to 120 gallons of crude oil per ton. It was exhausted in a dozen years and oil shale was used. It yielded 45 to 18 gallons per ton, with ammonium sulphate 35 to 70 lbs. per ton. Many thin seams of shale are found all over the coal fields of Britain and these were retorted in the early bright days of the industry. There was a considerable manufacture in Wales for some years. But foreign competition put all out of existence many years ago, except those situated in the Calciferous Sandstone. A hundred small works have been killed off in Scotland, representing a loss of some millions of pounds. The larger works were increased so as to be worked more economically and have continued to exist, sometimes paying dividends and sometimes not. The through-put of shale has always kept increasing, and last year was 3,000,000 tons, or, to be particular, 2,992,676 tons, according to Home Office figures. New oil fields may still be found in Britain. Oil shale has been discovered in the Western Islands in Raasay and Skye; there is an outcrop on the Northumberland coast; and we have always the Kimmeredge Clay stretching across England from Dorset to Lincoln and Norfolk with its thin seams of oil shale, yielding a very sulphury crude oil.

All over the world and through a great range of geological age there are abundant rich seams of oil shale ready to be worked when needed, and these give a certain world-wide interest to our little Scottish Oil Industry. There is, however, no necessity for exhausting all the resources of the world in this generation.

The mining of the shale is always getting more expensive. The easiest got at happened also to be the best and so now we have to go further and fare worse: we have to expend more money to get a shale which is poorer. It is more friable than the richer shale and gives a larger proportion of smalls. The shale in the retort is subjected to a current of steam to preserve the oil from breaking up, and also to create and protect the ammonia from decomposition. The presence of smalls in the retort prevents the free passage of the steam and endangers the local fusing of the spent shale and the destruction of the retort. To prevent loss of smalls we need special retorts to distil it either for oil or gas, and so keep it out of the ordinary retorts.

As it does not pay to carry the shale any distance to the retorts, the crude works with refinery are situated on the field of shale and each refinery has several crude works over its shalefield and

sends the crude oil to the refinery by railway tank. The setting point of the crude oil is from 80° and 90° F., and pipe lines are little used.

In the crude works the shale is retorted, producing: Crude oil, ammoniacal liquor, permanent gas, and spent shale.

The spent shale is not utilised at present; but I imagine a little enterprise and capital might produce from it products of value. Spent shale is more friable than clay and so more easily amenable to chemical reagents, but the heat it has been subjected to has made some constituents more difficult to dissolve.

The permanent gas is used as fuel for the retorts. Sometimes no other fuel is used; but generally producer gas from coal is required to help. The Pumpherston Company, at their Deans Works, distil the coal needed in Mond producers, recovering the ammonia, and the result is, I understand, most satisfactory. The first cost of the plant is a little heavy to a struggling company.

The ammoniacal liquor is distilled in vertical column stills in the ordinary gas works way. Milk of lime is introduced into the liquor to volatilise the fixed ammonia after the volatile ammonia, the carbonate, and the sulphide, have been distilled off. The ammonia gases are passed into saturators in which they are caught either by fresh sulphuric acid, when the crystals collect in a well and are lifted by a steam ejector and sent to the centrifugal to be dried; or by acid that has been recovered from the vitriol tar of the oil refinery. We use the oil of vitriol twice over in the refinery and then recover it for making sulphate. The sulphate made from the recovered acid is got as a solution. When this solution is neutralised by the ammonia, organic bases are set free and rise to the surface as a tar, and this tar retains the sulphide of arsenic and also the oxide of iron. The settled solution is evaporated down in a vacuum pan and sent to the centrifugal. With care we get a good coloured salt. A slight excess of ammonia is used to set free all the iron oxide. When approaching neutralisation and after it, some ammonia escapes through the solution; but the gases are passed through a vessel above where the next charge of acid is lying and thus the last trace of ammonia is caught. Neutral ammonium sulphate solution does not produce a good crystal and also, on heating, ammonia is given off, so a small quantity of clean acid is added to the liquor before evaporation to prevent loss of ammonia. Sometimes the sulphate is not put through a centrifugal but into a bin to drain dry. It takes a week or so, and meantime the material has become a solid rock and has to be quarried and passed through a grinding mill on its way into the bags.

The large amount of steam passed through the retorts produces a weak ammonia liquor, about 1 % of ammonia against 2½ % in gas works. So it is not so suitable for making concentrated liquor; and the proportion of sulphide is high and it is therefore expensive to make into pure ammonia solution. The Government prefer that we make concentrated liquor so as to relieve sulphuric acid for munitions of war.

If it had not been for the ammonia our industry would have ceased to exist long ago. In the early days burning oil was the principal product and our manufacture gave the common people a good cheap light for the first time, and its continuous existence has kept the price of lamp oil down I am sure to less than one-half of what it would otherwise have been. When this country was flooded with foreign lamp oil the retorts were changed to make heavy oil and solid paraffin. By and by when these came in in great quantities the retorts were lengthened to increase the sulphate of ammonia. The yield of sulphate was trebled. But with gas works, gas producer plants, iron works, coke works, all producing ammonia, and with Niagara and the waterfalls of the world harnessed up to create combined nitrogen from the atmosphere, there is nothing left to fall back on. Except, perhaps, that we may educate our farmers to use more ammonia and so increase the demand. No doubt the home-made sulphate of ammonia is a better and safer manure than foreign nitrate of soda, if only it be applied at the right time and the soil be kept neutral with small doses of lime. Nitrate tends to kill off the beneficent microbes in the soil that produce plant food, and ammonia encourages their increase. Nitrate is easily washed out of the soil. A field at Rothamsted by last winter's rainfall lost nitrate equal to 7 cwt. of nitrate of soda per acre. About 1880 when Peruvian guano got scarce the price of sulphate was £22, some even £24 per ton. By 1890 nitrate was imported in such quantities that the price fell to £8 per ton and I never expected to see £10 again. Nevertheless the demand increased in proportion and the price got for many years was £12 to £14. With Government and Parliament taking an interest in science I think the demand may increase with the supply and a price got that may keep this industry still in existence and able to pay a dividend.

The retorts are built into great benches about 60 feet high. The upper part of the retort is of cast iron and the lower part is of firebrick, with flue around in which the permanent gas is burned. Steam is introduced at the bottom of the retort and the distillation is upwards. There is a large hopper on the top to supply the shale as required, and mechanical arrangements below to take away the spent shale at a certain rate. So the movement down the retort is continuous, and about 4 tons a day are passed through each retort. The section is circular, tapering from 2 feet diameter at top of metal to 3 feet at bottom; or the section is oblong. In the metal part the oil is distilled out at as low a temperature as possible. The brick part is an ammonia and gas producer and is heated as highly as is possible without fusing the ash; and in this the fixed carbon is burned in steam and the nascent hydrogen produced unites with the nitrogen to form ammonia. The products of distillation are first passed through a water condenser, a tower in which water for the steam boilers is heated; then through great benches of vertical 4-inch pipes; then through scrubbing towers, of water to catch the ammonia, and of heavy oil to catch the light spirit. The gases are then caught by a fan which produces a slight vacuum back to the retorts, and a pressure in front to drive the permanent gas back to the retort flues. The condensed crude oil and ammonia liquor run together to a separator, where they instantly separate and each is run into its receiver. I sometimes think that in both water condensers and scrubbers we might get helpful suggestions from the gasworks; but we are all very conservative.

The crude oil has a specific gravity from 0·865 to 0·880 according to the shale, the form of retort, and the temperature of working. We have much to learn yet as to the best conditions.

The refining consists of fractional distillations; and treatments with oil of vitriol and with caustic soda solution; cooling and pressing of heavier oils for solid paraffin; and refining the solid paraffin by sweating. Two companies make candles. The distillations are always in the presence of more or less steam, more or less superheated. We have continuous distillation through boiler stills, with residue stills attached temporarily, in which the heaviest oil is distilled to dryness. Much valuable coke is got from the crude oil residue stills; and while coking great quantities

of very rich gas are given off for illumination or for fuel. This gas was allowed to escape into the atmosphere for many years in spite of the work of Beilby and McArthur, but is now saved; and light spirit is got from it. Dephlegmators are used to help the fractionation of the oils but might be more used. Fractional condensation might also be more used both at the shale retorts and the oil stills.

The oil of vitriol carries down, as a black tar, the bases like pyridine, the more unsaturated hydrocarbons, sulphur compounds, a proportion of phenols and benzenes. Besides these there seem to be substances held in colloidal solution which are precipitated by the acid. The amount of oil of vitriol is limited so as not to take out the olefines. The acid seems to have little polymerising influence. The caustic soda solution takes out as a black tar phenols, sulpho acids and any definite acids present. The acid tar is washed free from acid with hot water, settled and burned as fuel under the stills, blown into a spray with superheated steam. The soda tar is made slightly acid with vitriol tar water, settled, and burned also. The tars have never been thoroughly examined. Some definite organic bases have been separated and examined, some also of the phenols; but there are indefinite compounds in the tars we know nothing about, and being easily decomposed might perhaps be the foundation for useful compounds. In the phenols we have large quantities of most valuable compounds that ought no doubt to be separated and utilised as antiseptics. Over 20% of the crude oil is got as tar, easily and cheaply used as fuel oil, and therefore quite valuable; but no doubt many of the substances present if separated would be very much more valuable. Two of the Companies make their own oil of vitriol.

One good result of the war is that it has forced us to causticise the soda for ourselves. The war has greatly increased the price of our products, but it has at the same time greatly increased the cost of metal materials, wood, coal, labour, etc., We have difficulty in getting coal enough to keep us going, difficulty in getting materials forward in time, difficulty in getting men to do our repairs, etc. Many hundreds of our best experienced men from mines and works have joined the army, replaced to some extent by any kind we can get. Oil works working in three shifts is not the most suitable situation for women, but we do what we can, and have women in the offices, candleworks, and other possible places. After all we cannot keep the works going at the full pace that pays best.

It has been suggested that if oil shale gets scarce the Scotch companies should tackle the question of getting the same products from peat. That is a difficult problem; but it is satisfactory to know that in Ireland at Portadown there is a successful production of power from peat gas.

References.

In this Journal for 1897, the history of retorting is given by Beilby, p. 876, by Henderson, p. 984. Retort is described by Bryson, p. 990, by Crichton, p. 988. Refining 1889, p. 100. Ammonia from shale—Beilby, 1884, p. 216. Paraffin cooling, 1885, pp. 321, 653.

DISCUSSION.

The PRESIDENT said that it was interesting to hear that Mr. Steuart held out hope that the leading oil companies would cease to engage in ruinous competition and would meet together and unite their skill for the common good, and he hoped that those expectations would be realised. He had every reason to believe that the gas works were deeply indebted to the shale oil industry. Many years ago he had visited Broxburn, with some prominent gas engineers, and it was a matter of very considerable discussion amongst them as to how far the methods that had been adopted successfully at Broxburn should not be applied in connection with gas practice. In the end it came about that one man closely associated with the oil industry (he thought it was Mr. Young) co-operated with the gas engineer in charge of one of the corporation undertakings with the result that they had evolved a vertical retort, embodying many features of the retorts used in distilling shale.

Mr. R. MACLAURIN suggested that, as the continuous application of sulphate of ammonia was rather harmful to the soil, it might be a good thing to send out a mixture of ammonium sulphate and calcium carbonate.

The PRESIDENT said that some of the difficulties which had arisen from the use of sulphate in past years had been owing to the belief that it could be used alone under all circumstances, but that belief had not been well founded. Of late years a large proportion of the sulphate of ammonia in this country had been more or less in the hands of the Sulphate of Ammonia Association; the original idea was to do the same with sulphate of ammonia as was done by the Nitrate of Soda Association, and it had worked exceedingly well. They had realised that it was not possible to administer doses of sulphate of ammonia everywhere in the same way, regard having to be paid to the character of the soil; that had now been systematised and special mixtures for different soils and different crops were recommended.

Mr. STEUART said that there was a tendency for rather too much sulphuric acid to be applied to the soil as dissolved phosphate, etc., resulting in finger and toe of turnips, among other things. But when the soil was treated with small doses of lime either in the form of carbonate or caustic to keep the soil neutral, then full value would be got from the ammonia. If sulphate were applied to acid soils the bacteria caused the destruction of part of the ammonia. If it were applied early in the year, with the soil neutral, the ammonia would be preserved and not washed out by the rain, as with nitrate of soda. The farmers very often made the mistake of not applying sulphate early enough. Properly used, sulphate of ammonia was a better and safer manure in every way than nitrate of soda.

On Wednesday evening the members were entertained at a Social Meeting by the Local Section, in the Dining Hall of the University Union. Music was provided by Mr. Constantine and Dr. Inglis Clark.

SECOND DAY.

THURSDAY, 20TH JULY, 1916.

THE INFLUENCE OF THE EUROPEAN WAR ON THE TAR DISTILLATION INDUSTRY.

BY W. H. COLEMAN.

In order to show how the outbreak of war has reacted on the industry, I would direct your attention to the following table in which I have gathered together the quotations for the most important tar products given in the first issue of the Journal of Gas Lighting for each quarter of the year commencing January, 1914. I have taken the highest figure in each, and only one quotation for each article, in order to avoid confusion:—

Immediately after the outbreak of war prices were so irregular that for several weeks no quotations were given, but by the beginning of October, 1914, they were being issued again. It should be noted that the quotations for crude tar, October, 1914 and January 1915 were based on the liquid

products only. It is unnecessary to say any more about the quotations for tar, as they are governed by the prices of the products.

dross, etc.) briquetted, we should not only obtain an increased permanent home market for our pitch, but we should utilise our coal resources in a better

TABLE I.

		1914.				1915.				1916.		
		Jan. 6.	Apr. 7.	July 7.	Oct. 6.	Jan. 5.	Apr. 6.	July 6.	Oct. 5.	Jan. 4.	Apr. 4.	July.
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Crude tar	per ton	31 0	29 6	28 3	17 3	18 6	25 0	25 6	24 3	22 6	20 0	19 3
Pitch	per ton	39 6	37 6	32 6	—	—	18 0	23 0	21 6	16 6	15 6	15 6
90% benzol	per gall.	1 0	10½	9	10	9	10½	11	11	11½	11½	11¼
50/90% benzol ..	per gall.	11	10½	10½	10½	1 4	1 4	1 4	1 4	1 4	1 4	1 4
90% toluol	per gall.	—	11	11	1 3½	2 4	2 4	2 4	2 4	2 3	2 3	2 3
Crude naphtha	per gall.	5¼	5¼	4¾	5	5¾	5¾	6½	7	7	7	7
Solvent naphtha ..	per gall.	9¾	9¾	9½	10	1 0	1 7	1 11	2 0	2 1	2 0	1 10
Heavy naphtha ..	per gall.	9½	9½	9½	1 0	1 0	1 1	1 3	1 3	1 3	1 3	1 3
Creosote	per gall.	3⅛	3¼	3⅜	3½	3 7/16	3⅛	3 1/16	3	2⅞	2⅝	2¼
Heavy oil	per gall.	3⅞	4	4⅛	4½	4½	4	4	4	4	4	4
60's carbolic acid ..	per gall.	1 1½	1 1	1 2	2 2	3 0	3 5	3 6	3 6	3 5	3 4	3 4
95% cresylic acid ..	per gall.	1 1	1 0	1 0	8	1 4	1 6	2 3	2 6	2 6	2 8	2 8
Crystal carbolic ..	per lb.	3½	3⅛	3⅛	—	1 4	1 3	1 6	1 6	1 4	1 4	1 3
Naphthalene salts ..	per ton	60 0	60 0	60 0	55 0	65 0	75 0	80 0	80 0	80 0	80 0	80 0
Anthracene A	per unit	1¾	1¾	1¾	2	2	2	2	2½	2½	2½	2¼

Taking the items in their order, the price of pitch fell considerably; this was due to the stoppage of exports. According to the Bulletin issued by the Commercial Intelligence Department of the Board of Trade in October, 1914, during the year 1913 pitch to the value of over one million pounds sterling was exported and of this, £297,000 worth was sent to Belgium, £472,000 worth to France, £119,200 worth to Italy, and practically none to Germany. The greater part of this pitch was used for the manufacture of briquette fuel, and as the whole of the coal-producing districts of Belgium and the most important districts of France are in the enemy's hands, some considerable time will most probably elapse before these markets are again available, and very considerable stocks must have accumulated. Several proposals have been made to find outlets for the surplus of pitch; amongst others it has been proposed to mix a proportion of pitch with the coal charged into the gas retorts. So far the reports as to the results obtained are somewhat conflicting. The most complete report published up to the present is contained in a paper which was read at Birmingham on June 24th last by Mr. E. W. Smith, M.Sc., chief chemist to the Birmingham Corporation Gas Department. From a consideration of his figures it would appear that so far as gas works pitch is concerned, this method of disposal can only serve as a means of reducing stocks, and is not likely to continue after the present trouble is over. It has also been suggested that non-coking coal might be rendered fit for coking by adding a proportion of pitch before charging into the ovens. So far as I have been able to ascertain no results have been published, and it would at first sight seem to be unlikely that any great success can be hoped for, since most coking coals lose their coking property when exposed to a temperature of about 400° C. It is possible that low temperature pitches, such as those obtained from producer and blast furnace tars, may be more suitable for this purpose than those from gas works, and coke oven tars, as they have been obtained at a lower temperature. It is, however, well worth while giving some time to the investigation of this proposal as, should success be obtained, it would open out very considerable possibilities.

There is, however, one direction which I think holds out considerable promise and that is the extension of the briquette industry. Very large quantities of slack coal are produced and used as fuel and if the slack were washed, the nuts being used for fuel direct and the fines (duff, smudge, dross, etc.) briquetted, we should not only obtain an increased permanent home market for our pitch, but we should utilise our coal resources in a better way and should contribute to the reduction of black smoke.

The very large quantities of coke breeze might also be usefully formed into briquettes and utilised. The production of briquettes in the most important European centres in 1909 is given below:—

Belgium	in 1909 produced	2,707,390	metric tons.
France	,, ,, ,,	3,061,300	,, ,,
Germany	,, ,, ,,	18,748,713	,, ,,
Great Britain	,, ,,	1,511,645	,, ,,

In the case of Germany the greater part of the briquettes were produced from brown coal.

The most recent figures for Great Britain are:—

1913	2,213,205 long tons.
1914	1,840,465 ,, ,,

I have dealt somewhat at length with the question of pitch as it forms by far the greater proportion of the crude tar and presents I am afraid the greatest problem for the future.

Turning next to benzol and toluol both have appreciated in value. The former is in demand not only for the production of synthetic phenol and consequently for picric acid, but it has served as the starting point for the production of synthetic toluol, and has taken the place of a considerable quantity of petrol as a motor fuel for which purpose it is excellently suited. Toluol of course is the starting point of trinitro toluol or T.N.T. and the demand has been so great that not only are practically all coke oven works recovering all the benzol and toluol possible by washing the gas, but the process has been extended to the gas works. When the demand for high explosives decreases, other outlets for these products will have to be found, and although the revival of the colour industry in this country will require large quantities it is probable that we must look to the use of both benzol and toluol as motor fuels to absorb the balance of the very large quantities that will be produced. In admixture with alcohol they offer one of the best solutions to the questions of providing a home made fuel for internal combustion engines.

The naphthas have advanced considerably in price, but they will probably fall back to their old position again.

Creosote has suffered somewhat, but has, I think, a fairly bright future as a fuel for engines of the Diesel type in addition to its ordinary uses.

Carbolic and cresylic acids have risen very considerably not only because they form the starting point of picric acid and trinitro cresol, but because of their value as disinfectants. With the ending of

the war they are likely to revert to their former position, and it is to be hoped that further research will show that the synthetic resins of the Bakelite type produced by condensation of phenols with formaldehyde and the so-called synthetic tannins formed by the condensation of sulphonated phenols with formaldehyde have a bright future.

Naphthalene has risen considerably and will probably maintain a fairly high level especially as the extension of vertical retorts will tend to decrease its formation.

Turning from the products of distillation to the works where the process is carried out, you will find in the next table the number of tar distillation plants registered separately under the Alkali Act, which I have taken from the reports of the Chief Inspector. For the figures for 1915 and 1916 I am indebted to the kindness of His Majesty's Chief Inspector, Mr. Curphey.

TABLE II.

Year.	Number of separate tar distillation plants.
1906	174
1907	184
1908	188
1909	191
1910	195
1911	205
1912	221
1913	234
1914	250
1915	296
1916 to 30th June	356

The rapid increase in the number of works during the last few years has been due not only to the erection of tar distillation plants at coke oven works, but to the installation of tar dehydrating plant at the gas works for the production of refined tar for use in making and surfacing roads. These plants are mostly small and of the continuous type. The systems of Wilton and Hird appear to be very successful in solving the question of the production of refined tar on the spot where it is required, and saving considerable unnecessary carriage.

In conclusion let me say a few words as to the future, and I will confine myself to the actual tar industry and leave the question of colours to abler hands than mine. Since its birth in this country the methods employed in separating the fractions have followed very largely on the original lines, and the industry has suffered from a lack of co-operation among the workers. I quite realise the difficulties in the way of such co-operation, but I feel sure if we are to recapture the fine chemical and colour trade from Germany, we must be prepared in the future to give a good deal more scientific attention to the tar industry than has been the case in the past. I will briefly indicate some of the work which might be undertaken by a combination of those engaged in the industry.

A central research laboratory might be established where many questions could be thoroughly thrashed out, some of the most urgent are :—

The cause of corrosion in tar stills.

Is the present method of separating the fractions the best in view of the products required.

An investigation of creosote oil and of the lesser known bodies in the distillates with a view to finding uses for them.

An investigation of coal gas pitch to find means for rendering it less brittle when cold and raising its melting point, so as to render it, if possible, more suitable for replacing natural asphalt.

The standardisation of the methods of testing coal tar products.

Meetings might also be held from time to time to discuss ways and means of preventing useless competition and conferences might take place with representatives of the gas making and coke oven industries to discuss questions of mutual interest.

Many other suggestions might be made but the whole can be summed up by saying that our great need is organisation and co-operation, so that we may take advantage of all opportunities of improving the prospects of the industry.

DISCUSSION.

The PRESIDENT said that co-operation was needed in distilling tar, as in so many problems, he found some difficulty in understanding why the continuous method of distillation had not made greater progress in this country. It was so simple, and almost automatic in action. The regularity with which all the operations were conducted was an exceedingly good example of what should be aimed at.

Mr. E. F. HOOPER stated that the prices given in the paper were not commercial prices in the ordinary acceptation of the word. Benzol or benzene in its various grades probably would yield a very much higher price than was indicated. The prices given were the prices at which the Government required benzol to be delivered. That applied also to other products, but he thought that Mr. Coleman might have indicated the value of naphthalene at a considerably higher figure. He did not think with regard to the question of the disposal of pitch in the future, that they need trouble as to the necessity of putting the pitch back into the retorts. There was not much doubt that after the war was over pitch would again find its normal level in the ordinary manufacture of briquettes; and if the price of coal remained at its present high price, probably as much pitch as could be made would be required not only in England but abroad for the conversion of more or less low value duff and very small coal into high grade fuel in the form of briquettes. The bulk of the coal won abroad yielded a much larger percentage of small coal than that raised in England. Neither the gas companies nor tar distillers need fear but that pitch would resume its normal condition very shortly after the termination of the war. It was to be hoped that the war had resulted in some uses being found for products of which very little was known at present, such as solvent naphtha and creosote products. There could be little doubt that research work in that direction would discover products of considerable value. If there were a little more open-handed interchange of ideas in that class of work, no doubt great improvements might be made in connection with these particular products.

Mr. R. MACLAURIN said that he had found with low temperature pitch that the change from softness to brittleness came very quickly, and was evidently accompanied by decomposition, because a large volume of fume was evolved. Experiments he had made indicated that by the use of solvents it might be possible to obtain different products from high temperature coal tars. When a low temperature tar was treated with weak sulphuric acid or paraffin oil, and the cresyli acid or carbolic acid separated, the light portion could be used directly for lubricating purposes. A resinous mass also separated, which could be used for varnish-making. Probably in higher temperature tars the aromatic hydrocarbons to a large extent dissolved the resins, and it was possible that pitch was actually resinous material soluble in aromatic hydrocarbons. It was possible that the resins formed in low temperature tars were somewhat similar to bakelite, and might be formed

by the phenols combining with aldehydes after the tar had left the retort. In the low temperature tars obtained by his process, he found that in the portion soluble in caustic soda there was a little cresylic acid, practically no carbolic acid, and a very large quantity of resinous material.

Mr. W. Irwin thought a better idea might have been obtained of what might be called the open market value of certain tar products by the prices which could be obtained in the United States. Whilst the Government was now paying 10d. and 11d. per gallon for benzol here, in the States 4s. was being paid. In the case of the other products, the prices were much in the same proportion. With regard to the first question put by Mr. Coleman, it was difficult to say if the present method of separating the fractions was the best, because tars varied so much that no general statement could be made. That there ought to be more co-operation was a good suggestion, and in no industry would it pay better than in the tar industry.

Dr. C. H. Desch suggested that the constitution of blast furnace tar should be added to the subjects calling for investigation. The custom seemed to be to treat blast furnace tar as an inferior variety of gas tar. It did not contain several very important constituents of gas tar, but practically nothing had been done to determine whether it contained other constituents which might be utilised. The fractions were not used, he thought, to the best advantage. It was a subject which had not received any thorough investigation. It was practically a local industry, but in some districts it was of quite considerable importance.

Mr. W. Newton Drew was rather surprised that the new Association of Chemical Manufacturers had not been mentioned. One of its most valuable functions would be, he presumed, to form sections—*e.g.*, a section of tar distillers, to deal with the subject in a co-operative way from every point of view. He was afraid that the British nation had not a very great genius for co-operation. Most of the triumphs of the past seemed to have been made by individuals, but if we were to do great things in the future we must co-operate and we must even give each other wrinkles with a certain risk that we might thereby suffer some loss; in no other way could we reach the level of the enemy and surpass him.

Mr. G. Stanley Cooper expressed the opinion that one of the greatest bars to co-operation was the fear of showing others the work we were doing. Until more mutual confidence was shown he was afraid co-operation would be very limited.

Mr. J. K. Hill mentioned that in the Corporation Gasworks at Widnes a large amount of tar was decomposed in retorts and the gas produced was added to the coal gas. It might be possible to distil pitch without attempting to mix it with the coal.

Mr. J. T. Dunn emphasised what Mr. Hooper had said about the possible uses of pitch in the future. In some of the larger Northumberland collieries where more and more complete methods of washing and separating the coal had gradually been adopted, briquetting plant was being put down on a very considerable scale with the view of avoiding the whole of the waste of fine coal. He contrasted the remarks that had been made urging the necessity for co-operation, with the request on the programme of the Edinburgh meeting, to members attending the meeting not to visit works where there were industries in which they were personally interested.

The President said that probably the insertion of such a request to members was the only way in which permission could sometimes be obtained to visit works. When face to face with a body of foreign manufacturers, we must sink our jealousies, even although we had to give away a little of our knowledge to each other, in the hope that we should gain a great deal in our competition with highly organised producers. We must teach each other how to fight the common antagonist in industry. A great deal of advantage might be obtained from collaboration or unity of purpose between those who produced the tar, and those who distilled it. At the present moment there was none, or very little indeed; the tar producer had no regard as to whether the article would give the best products. If some of his defects could be pointed out to him there would be mutual benefit. At one time the works with which he was associated had made tar containing hardly any benzol and much free carbon. By adopting more scientific methods they had been able largely to increase the benzol and substantially to reduce the free carbon.

THE EXTRACTION OF TAR FOG FROM HOT GAS.

BY G. T. PURVES, A.M. INST.C.E.

The question of completely removing tar fog from hot gas has arisen only in comparatively recent carbonising practice. It is seemingly an operation of considerably more difficulty than complete extraction from cooled gas. Up till about the advent of direct and semi-direct ammonia recovery the methods in use for effecting the removal of tar fog were determined almost solely by the need for maintaining a minimum standard of purity and illuminating power of the permanent gas, and that as cheaply as possible. The question of tar values did not arise. The tar extractors proper were placed late in the series of plant units through which the gas had to pass. On this account the bulk of the tar was separated before the tar extractor was reached and the gas and its remaining tar content cooled to about atmospheric temperature. As a result the extraction of that remaining tar fog was a comparatively easy operation. In direct recovery the gas must be freed from tar fog before it enters the saturators, thus reversing the order of arrangement on the older indirect system. It was on account of the inefficiency of the tar separation from the hot gas that Brunk's direct ammonia recovery process was a commercial failure.

Now consider the treatment of the gas during the cooling. As the crude gas passes through the collecting main and connections, etc., up to the outlet of the condensers its temperature steadily falls, and the motion of that part in contact with the metal surface is retarded. In this way the gas with its accompanying tar particles tends to roll from the centre of the stream on to the metal surface. The contact between tar particles and this surface must thus be very gentle. So that, since the bulk of the tar is usually separated during this period, we are led to the conclusion that if the proper means are applied tar extraction should entail the expenditure of little energy per ton of coal carbonised. Yet we will see later that in the separation of tar fog from hot gas the expenditure of energy is very considerable.

Though the bulk of the tar is removed in the plant before the completely cooled gas reaches the tar extractors proper this is merely incidental to the cooling and is little the result of special provision having been made to increase the efficiency of extraction. Repeated bends in the mains by suddenly changing the direction of gas flow increases the separation, and so also does causing the gas to impinge on water cooled tubes set transversely in a cooling chamber. The fundamental factor in tar extraction, however, appears to be the control of the cooling, and in order to get the maximum tar

separation in the mains the gas must be cooled as early as possible to as near the minimum temperature required as is practicable. This is particularly important where hot tar extraction is to be carried out: for the fog which is formed just before the extractor is entered is very difficult to remove. It should be advantageous to cool the gas to practically the extraction temperature, then pass it through a long main carefully insulated to prevent further cooling, and then into the extractor. The behaviour of gas carrying freshly formed tar fog seems to me to present considerable analogy to a colloidal solution. If we had here a true suspensoid we could readily understand the difficulty of extracting the freshly formed fog. Lowering the temperature of the gas materially below that at which the fog is formed certainly facilitates extraction. Wm. Young proposed to promote the separation of tar by condensing naphtha vapour on the fog particles, and you will remember Aitken proposed to send the gas at 190° F. into a settling chamber, and to keep it there as long as possible at that temperature. These methods of procedure all illustrate the analogy and I think suggest the ideal treatment the gas should receive during the cooling. The temperature named by Aitken is not much above the water dew point temperature of the gas when wet dross is being carbonised, and it would be interesting to know if he considered the fog formed at this temperature the most difficult to extract. In any case on direct recovery plants the application of a settling chamber must be at least just above the water dew point temperature. Reference has already been made to the separation of tar particles by contact with the sides of the main. In this way the surface becomes coated with a film of tar oil, and as Young and others have pointed out, this facilitates the removal of the fog. When the gas temperature falls below the water dew point and the main surface gets coated with water, there is not the same adhesion to the tar particles. From this it might be inferred that after the dew point was passed the tar separating power of the mains would decrease. Against this however there is the fact that as the condensation of aqueous vapour reduces the volume of the gas the concentration of tar particles will increase, and also more light fog will be formed. I have noticed that the tar does seem to settle out more readily during aqueous condensation. When gas has been completely cooled light oils separate out, and probably condense to some extent on pre-existing fog. The lightest hydrocarbons, since they are not in sufficient quantity to more than saturate the gas, are removed solely by solution in the existing fog. These influences increase the mass of the fog particles, and so make the extraction easier. In the case of extraction from hot gas these actions have not occurred, and this is probably one of the factors contributing to the difficulty of extraction.

In order to see why hot tar extraction is so difficult we must consider the altered conditions of working. Some of the contributing factors have already been referred to. Direct ammonia recovery from hot gas has so far been applied only at coke oven plants (in this country at least). In these plants washed dross is used, and the coal when charged into the ovens usually contains from 9 to 13% of added water. This water is of course present in the gas as vapour at the fog extraction temperature, thus greatly increasing the volume. One might anticipate, as so much water accompanies the coal, and so cools the oven walls, that the outstanding effect of increasing the proportion of water would be the production of thinner tar possibly more difficult to extract. This is not my experience. The most notable effect is the increased amount of pitchy matter which is deposited in the collecting main—not necessarily an increase of pitch made per ton of coal. The increased dilution of the gas by steam will have little effect on the volatility of the pitch product. This will readily settle out, and so the fog formed later on should be lighter. But at the higher dew point an increased amount of the lighter tar will be retained in the gas as vapour, so counteracting the effect on the fog of the reduced pitch content. It is therefore not probable that the presence of so much water in the coal will make the fog extraction more difficult by the production of a lighter tar fog in itself. It might be, however, that under these conditions the fog particles are smaller, but it is very difficult to get experimental evidence in regard to this. We do not know how the composition of the individual fog particles is related to that of the bulk tar collected, but the rapidity of the cooling, and the time the fog particles exist as such in the gas will have a material influence on their composition and consequently on the difficulty of extraction.

On indirect recovery plants where the gas is completely cooled such a machine, as a Livesey Washer or a Pelouze and Audouin tar extractor, which gives a very simple scrubbing action, effects satisfactory extraction for the works purpose. They are not suitable for treating hot gas, however. At Auchengeich we have a baffle chamber on the Pelouze principle, and I find it of little or no use for extracting the tar.

The solution of the problem of hot tar extraction, with a reasonably small expenditure of energy lies in the treatment the gas receives before it enters the extractor. It being practically impossible to completely remove freshly formed tar fog—at least without a very large expenditure of energy—so the fog must first be brought to a suitable condition for extraction after which the type of tar extractor used is of secondary importance. An electrical method of modifying the condition of the fog is applied at the coking plant of the Semet-Solvay Coy., Detroit. The crude tarry gas is here passed through an intense ionizing field where according to the theory the resulting ions in their violent motion cause impact between the tar particles. "Because of this impact or for some reason as yet unknown agglomeration results and the dense tar mist is almost entirely dissipated leaving a relatively few large tar drops in its place.*" The tar is not extracted in this ionizer but in the tar extractor through which the gas passes next. It was found that the Pelouze and Audouin machine became a very efficient tar extractor after the gas had been treated in the ionizer. The electrical energy used in the ionizer must be added to that required for forcing the gas through the Pelouze and Audouin extractor. So that while this method may give very efficient extraction the consumption of energy will still be very considerable. The most satisfactory method of getting the fog into a suitable condition for extraction appears to be controlling the cooling of the gas. The design and arrangement of the gas mains at the Auchengeich plant are such as to make the cooling and detarring of the gas a very difficult matter but such results as I have been able to get indicate that this method should be satisfactory.

The ordinary devices used for fog extraction being ineffective, special methods have been applied, which give a much more intense scrubbing action. In the Simon-Carves direct recovery plant the heavier fog is separated in a "Cyclone" extractor into the inlet of which a jet of ammoniacal liquor is forced. This unit acts in the same manner as do bends on the mains. The principal extractor however, which removes the lighter fog is a "Dynamic" separator, the vanes of which revolve at high speed. The peripheral speed is

* Journal of Gas Lighting, Nov. 10, 1914.

said to be over 200 ft. per second. I have no experience of this type of extractor, nor do I know the details of its design. But I have passed crude gas at 80° C. through a five fan turbo-exhauster running at up to 2000 revs. per minute, and although the extraction was not complete the bulk of the fog present was certainly removed, and this exhauster was not specially designed on the lines of a dynamic extractor. The result of this test inclines me to the view that with such an exhauster working on cooled gas special tar extractors might not be necessary. The energy required in a dynamic extractor is said to be 1 H.P. per 12,000 cubic feet of gas per hour—presumably crude gas passing through the separator. When carbonising wet dross the volume of crude gas produced measured at the dew point will not likely be less than 20,000 cubic feet per ton. So that on a 360 ton plant the energy required per day will be about 600 H.P. hours. The method of extraction patented by the Otto Hilgenstock Company was to scrub the gas with a spray of tar. A cluster of sprays were used in Germany, and were so arranged that any particular number of them could be used at once. This practice was not exactly followed by the Otto Company in this country. The plant they erected at Auchengeich has four sprays, and provision is left for adding two others. These sprays can be worked singly or two sets of two in series. They are served by a motor driven centrifugal pump, the capacity of which is 120 cubic meters of tar per hour at high pressure, and they are designed for treating the gas from 360 tons of coal per day. Before handing over the plant the Otto Company abandoned the use of tar, and used instead a mixture of tar and liquor. They also used only one spray. I prefer to use liquor as free as possible from tar and a much smaller volume than that given above. The energy required at present per day is 360 H.P. hours. These figures show, in the designer's view, at least, the magnitude of the difficulty of completely removing the tar fog from hot gas. Other methods of extraction are in use, but I will not refer to them.

Following on the treatment of the gas as regards rate of cooling I have made experiments, with a view to saving energy, on the spray extractor itself, varying the dimensions of same, the nature of the liquid used, and the pressure and volume of the liquid not always, however, with gratifying results. As you are aware, the spray is applied inside a tapered pipe which is narrower at the top than the bottom: the spray and the gas both passing downward through this pipe or throat. Unless the throat is partially drowned with an excessive amount of liquor the extractor does some work as an exhauster, and so a considerable saving is effected at the exhauster proper. This shows that the spray is pushing the gas in front of it, when, for efficient scrubbing, it should pass through the gas beating out the tar particles in its passage. From this we conclude an excessive amount of liquor is being used. And a saving in energy will be effected by reducing this volume provided we can suitably apply the smaller volume to get the same extracting efficiency. Now consider the action of the Pelouze tar extractor, where the gas divided into small streams flows against an obstructing surface. We see that the efficiency of extraction will be determined by the fineness of the gas streams, and their relative velocity to the obstructing surface. It will come to the same thing if we consider small obstructing surfaces to be driven against the gas, with the same relative velocity, so dividing it into small streams. The efficiency will be increased if these obstructions are made smaller and placed closer together, and at the same time driven faster. We would very soon reach the limit at which the machine would be practical to construct and maintain. But this construction we are seeking is precisely what we have in a spray extractor. Thus we see the factors which determine the extracting power of the spray, and the lines along which increased efficiency must be sought. It is to be noted this pulverising of the spray is quite contrary to the practice of pumping relatively enormous volumes of liquor down the throat. The velocity of the particles of spray is determined by the pumping pressure. The fine subdivision of the spray is influenced by the pressure, but more particularly by the design of the spray nozzle. While considerable evidence is available regarding the discharge of liquid in solid jets from sharp edged orifices, there does not seem to have been much work done on the sprays formed when using orifices which cause the jet to burst. Experiment is therfore required to find the type of nozzle which will give the best spray. It is on the lines indicated that I have been experimenting, and while the results so far are very promising, I have not yet got sufficient data to refer to in more detail. As a result, however, I am hopeful that efficient extraction will be got with a further saving of possibly 70—90% in energy.

Tar extraction from hot gas apart from producer plants is practically limited to the relatively few carbonising works adapted for direct ammonia recovery, but the number is increasing, and I am convinced that before many years have passed direct ammonia recovery will be almost general, at least on new carbonising plants. While hot tar extraction is an essential in direct recovery, it is also the key factor to a further lucrative possibility in carbonising, *i.e.*, fractional collection of tar. It is to be expected that in future the recovery of benzol and its homologues will be carried out at gas and coke works to a greater extent than hitherto. This leads to the question what is to be the standard practice? Are we to distill the tar, produced in bulk by completely cooling the gas, for one portion, and wash the gas for the remainder, or will we adopt the more rational practice of simply washing the gas, and in this manner recover the whole benzol content in one operation? If the latter course is adopted the tar fog must be removed from the hot gas, and probably the ammonia recovered by a direct or at least semi-direct recovery process. When direct ammonia recovery is practised a small tar fraction is separated when the gas is completely cooled prior to washing with creosote. This fraction consists of naphthalene together with phenols and some heavy naphtha. We have thus a marked step towards complete fractional collection of tar, and it is surely a natural development to complete the fractional collection. It appears to me that all the arguments which justify the production of ammonium sulphate direct instead of through the intermediary of a crude liquor also justify the production of tar products in primary fractions without the intermediary of a crude tar. Further than this, there is the question of the nature of the tar products themselves to be considered.

As I have already suggested tar has been treated at the carbonising works literally as a by-product. Little or no attention has been given in practice to varying the manner of extraction for the purpose, if possible, of modifying or increasing the value of the tar products themselves. Our knowledge to-day of coal tar products and their relative proportions is limited in great measure to the products resulting from what is really a semi-destructive process of distillation. One tar distiller informs me that he is satisfied that distillation of the tar increases the content of naphthalene and free-carbon, and also increases the bulk of the pitch fraction. Now that the refining of tar constituents and the production of derived products is receiving so much attention, it is surely of prime importance to examine our methods of

recovery and preliminary treatment, and see whether or not the highest commercial value is developed from this important carbonisation product. If the primary distillation of crude tar is to be avoided we must resort to fractional separation of the fog from the hot gas. I have already put forward some views on fractional collection of tar, and do not propose to more than refer to it here, nor will I attempt to examine the effect of distillation on the tar products, but one or two figures relative to the subject may be of interest.

The tars produced in the modern vertical retort differ greatly from those produced in horizontals and coke ovens. They in fact mark a step towards those produced in so-called low-temperature carbonisation, and to which we may soon be giving much more attention. In order to get some fresh figures I distilled under exactly similar conditions samples of these five tars :—

	I.	II.	III.	IV.	V.
	Heavy tar from direct recovery plant (coke ovens).	Tar from horizontal retorts.	Tar from Wilson continuous-intermittent vertical retorts.	Tar from Glover-West continuous-vertical retorts.	Tar from Woodall-Ducklam continuous vertical retorts.
	%	%	%	%	%
First runnings up to 110°C.					
Oil	trace	2·6	1·3	2·6	3·5
Water	7·0	2·2	1·7	3·4	7·1
Light oil up to 210° C.	1·5	5·2	4·5	8·7	6·7
Carbolic oil up to 240° C.	4·0	13·0	10·9	12·9	7·7
Creosote oil up to 270° C.	8·4	9·1	12·1	8·6	8·6
Anthracene oil up to 350°C.					
Water	—	0·5	0·5	0·1	0·6
Oil	19·6	20·6	27·0	20·4	27·1
Pitch	58·6	46·0	40·6	41·5	37·2
Loss	0·9	0·8	1·4	1·8	1·5
	100·0	100·0	100·0	100·0	100·0

I. and II. contained both naphthalene and anthracene. III., IV., and V. showed no precipitate of naphthalene on cooling the oils. IV. and V. appeared to contain only a trace of anthracene, but the fraction when cold was semi-solid on account of the separation of solid paraffin. No. III. had not so much paraffin, but had a distinct amount of anthracene.

These tars so widely dissimilar are mixed at the tar distillery and submitted to a uniform treatment. It may not be practical for tar distillers to deal with the different types of tar separately, but there does seem good reason for giving them selective treatment, and if fractional collection was adopted at the carbonising works each tar could receive the fractional separation most suited to its composition. Both anthracene and solid paraffins are valuable products, and well worth recovering, but when the tars are mixed the one substance fouls the other. Vertical retort tar, particularly when mixed with other heavier tars, might be expected to suffer more from decomposition during distillation, since it has not been cracked to the same extent during carbonisation of the coal. Specifically light tars yield more gas when they are being distilled. I tested three samples of the gas evolved during the distillation of a 20-ton charge. The first sample was taken when spirit was just commencing to come over. It was mostly air and steam and contained little hydrocarbon gases. The other two tests were as follows :

	II. Still head temp. 170° C. after 10½ hours firing.	III. Still head temp. 225° C. after 26 hours firing.
	%	%
Absorption by 10% sulphuric acid	7·2	15·9
CO_2, H_2S, and SO_2, etc.	8·4	20·2
C_nH_m (by bromine)	2·1	2·5
CO	6·7	3·4
H_2 *	33·1	25·9
CH_4 *	31·0	22·9
N_2	12·0	9·0
	100·5	99·8

* The result of combustion was calculated as if only hydrogen and methane were present.

These tests are not of much significance, the volumes of gas not being known, but it seems unlikely that after 26 hours firing and at this temperature that the gas evolved was simply dissolved in the tar.

These notes are not a complete statement of the problem of hot tar extraction, but they are a record of some of the conclusions we have arrived at, and may be of interest to others working on the same problem.

Discussion.

The President said that the paper dealt with an important aspect of the recovery of ammonia by the direct process. The success of that process depended upon the completeness with which the tar fog was extracted before the absorption of ammonia took place. It was surprising that in a works carbonising 360 tons of coal a day 360 horse-power was required to work the tar sprays. He would have thought that the horse-power required under these circumstances would be something like five or six for a similar quantity of coal per day.

Mr. R. H. Clayton asked what method was used to estimate the tar fog in the gas. To get an accurate test of the tar fog they had found it necessary to take the samples one third of the way through the main. To prevent tar fog being formed due to further cooling, a glass tube was inserted into the main with the orifice pointing downwards, so that the tar would not drop into it from the top, the tube was filled with cotton wool and gas sucked through. Afterwards the cotton wool was extracted with benzol and the amount of solid material calculated, allowance being made for the free carbon. By this method it was possible to test the gas in the main at the exact temperature, with the conditions unaltered. Working with the Livesey washer at 2 in. back pressure, they had obtained 95% efficiency. The Pelouze apparatus gave 98% efficiency when worked at 4 in. back pressure. For water-gas the highest efficiency was obtained with a Crossley fan, but that was only when the peripheral speed reached a certain limit. None of these, however, gave the desired result, as it was not possible to get a spent oxide free from tarry matter—it always contained 3 to 4%. The figures that Dr. Carpenter had called attention to, 360 tons of coal requiring 360 horse-power, were, he agreed, enormous.

Mr. R. Maclaurin said that he was using just now a plant dealing with two million cubic feet per day—that was the gas from about 20 tons of coal—and the horse-power used for pumping all the water and all the acid liquor required, and running the centrifugal scrubbers, was always below 5 horse-power. His difficulty had always been to get anything past the scrubbers at all. Petrol had been added to increase the illuminating power of the gas, but all the petrol had been absorbed in the scrubbers. The gas left the plant at about 212° F. and passed through two centrifugal

scrubbers, 10 feet high by 4 feet in diameter, working at about 500 revs., and these scrubbers could scrub two million cubic feet of gas per day, quite effectively. His own results indicated that all the oils and all the ammonia were extracted by the time they left the second scrubber; that he attributed largely to the rapid swirl in the scrubbers. Regarding the fractional separation of the oils, he had found the heavy paraffins had been carried forward into the second scrubber. Naphthalene would be even more troublesome to get rid of, since it would almost certainly be carried forward, and that might be the reason of the very large horse-power required in the case Mr. Purves had been dealing with.

Mr. PURVES, in reply, said that in direct recovery processes an excessive amount of energy was used for tar extraction. The 360-horse-power hours which he at present found necessary was, in his opinion, too much. The method he used in testing was to collect the tar, at the fog extraction temperature, on tightly packed wool and the efficiency of the different tests was compared by the appearance or weight of the tar deposits. At no time had he got a test absolutely free from tar. The tests were made at the bottom of the extractor. Fog extraction became easier when the gas temperature fell below the water dew point. Mr. Maclaurin's figure of 5 horse power per hour (equal to 120 horse-power hours per day) was, in his (Mr. Purves') opinion, high for treating the gas from 20 tons of coal (that being the amount Mr. Purves understood was carbonised).

THE BRITISH COAL TAR COLOUR INDUSTRY AND ITS DIFFICULTIES IN WAR TIME.

BY C. M. WHITTAKER, B.SC.

On the outbreak of war in August, 1914, the manufacture of coal tar colours as an industry in Great Britain received a sudden and unaccustomed attention which was almost overwhelming to the few British chemists actually engaged in it. When it was realised that the trade was practically monopolised by the Germans, a perfect flood of ill-informed statements, exaggerations, and absurd suggestions were published in the newspapers and journals of this country.

I will just deal briefly with some of the commonest mistakes which were made with reference to the German coal tar colour industry during the discussions.

The most frequent mistake was in regard to the amount of capital which the German firms were supposed to employ in their industry. It was freely stated by Members of Parliament and others that the capital of the German industry was anything from one to two hundred millions. This was, of course, absurd, but such statements did not make any easier the task of those who were endeavouring to establish an adequate British industry. The export value of German coal tar colours throughout the world was for the year 1913 £11,349,100; add to this the German home consumption at a generous estimate of £2,000,000, making a total turn-over of £13,349,100. The capital of the German industry was £13,500,000 in 1913, showing that the total annual production was approximately equal to the capital. Those who talked about one and two hundred millions capital never stopped to explain how a dividend of from 12—25% could be paid on this capital out of an annual turn-over of £13,500,000.

Another point with which I wish to deal is the supposed dependency of Germany on outside countries, particularly Great Britain, for many of the important raw materials of the coal tar colour industry. Such a state of dependency was no doubt existent in the earlier days of the industry, but the modern coke-oven recovery plant has largely altered that state of affairs, as the following official figures for the year 1913 of the imports and exports of important raw materials connected with the industry show. In considering these figures I would ask you to bear in mind the fact that Germany's export represents the surplus after all the requirements of her home industry have been satisfied. Starting with benzol, toluol, etc., Germany exported 41,287,000 kilos. and imported only 6,709,600 kilos. These products do not give much of an opening for crippling tactics. To these figures ought to be added 7,264,700 kilos. aniline oil and salts exported by Germany against a negligible import of 156,100 kilos.

In 1913 Germany imported 4,155,200 kilos. of carbolic acid and exported 3,601,700 kilos., an adverse balance of roughly 500,000 kilos. It was well known by the tar distillers that the Bayer Co. were making an onslaught on the British market with synthetic carbolic acid which would have effectively reduced the amount of pure carbolic acid distilled from coal tar in this country. It must also be remembered that Germany will have made enormous quantities of synthetic carbolic acid during the war, so that under no combination of circumstances could its industry run short of carbolic acid after its experience of production during the war.

Passing on to naphthalene, Germany imported 5,248,700 kilos. and exported 6,151,110 kilos., in addition to 3,106,400 kilos. of naphthols and naphthylamines.

I now come to anthracene, of which Germany imported 1,286,000 kilos. and exported 277,400 kilos. There the balance is decidedly against her, and it is the only important raw product for colour manufacture in which Germany is deficient. It is the starting point for alizarin and many of the most important vat colours, which latter have added so much to the prestige of the German firms. It must, however, be remembered that bromine enters largely into the constitution of many vat colours, which gives Germany an effective counter against the withholding of anthracene.

Another point which was freely discussed as one of the virtues of the German firms was their service of technical chemists to demonstrate processes in the dyehouse. The Germans were not alone in supplying that service. I have had charge for fifteen years of the experimental dyehouse of Read Holliday and Sons, Ltd., now merged in British Dyes Ltd. During that period we have supplied, and are still supplying similar technical service in many dyehouses of different trades. One of our most recent services was to show a firm how to get 33% better value out of a dyestuff which they had used continuously for 18 months and which they had been consistently running down the drains for that period. In peace times there was often a difference between the British and German technical experts, namely, the Germans were given access to many places denied to the British.

I now propose to pass on to the handicaps under which the British coal tar colour industry has been and is labouring.

One of the greatest handicaps has been the shortage of chemists. On the outbreak of war I doubt if there were twenty British chemists who had had actual up-to-date experience in the manufacture of coal tar colours on the commercial scale. Of those who had had experience some had their energies diverted to the manufacture of explosives to the detriment of coal tar colour manufacture. It was an inevitable result of the close inter-relation between high explosives and coal tar colours. No complaint is made of the diversion of this energy, but it requires to be stated as one of the definite handicaps of the industry during war time. There was no reservoir of trained chemists from which to draw, so that University

trained men of good theoretical knowledge but no practical experience have had to be taken, and naturally some time must elapse before they become adapted to their new conditions. The outbreak of this war, bringing in its train the enormous demand for supplies of high explosives on a scale hitherto not contemplated, illustrated how closely inter-related was the manufacture of coal tar colours and high explosives. As everybody is aware, the two high explosives most largely in use are picric acid (or trinitrophenol) and trinitrotoluol. The latter requires similar apparatus to that which is used for making compounds like nitro-benzol, so essential in coal tar colour manufacture. The engineering trade has been so much occupied in connection with the supply of munitions that it has been difficult to get delivery of the plant for the necessary extensions. For the same reasons there has been a shortage of the skilled fitters necessary for the erection of the plant and of men to erect the necessary buildings. In fact the shortage of labour confronts one at every turn. The increases in the prices of copper and lead, which enter largely into the apparatus used in coal tar colour manufacture, have also added enormously to the cost of such plant.

The lifeblood of the coal tar colour industry is sulphuric acid, fuming sulphuric acid, and nitric acid. It is the misfortune of colour manufacture that it is impossible to make any colour without the use of nitric and sulphuric acids, the latter being required in various strengths of fuming acid from 70% down to 20% SO_3 and D.O.V. These self-same acids are also indispensable for the manufacture of the two high explosives lyddite and T.N.T. It is a matter which admits of no argument that the demand for acids for the manufacture of high explosives must take priority over their numerous industrial uses. In that fact you have the greatest handicap of the British coal tar colour industry, because, as is well known by every acid consumer, the supply of acids is nothing like equal to the demand.

Amongst the raw or primary products of the coal tar colour industry the four most important are benzol, toluol, naphthalene, and anthracene.

The distribution of one of these products (viz. toluol) is controlled by the Government. The amount of toluol to be distilled from coal tar has very definite limits, which are relatively small, so that the reason for this control is obvious. Benzol is the starting point for the manufacture of synthetic carbolic acid, of which so much is being made at the present time owing to the demand far outstripping the production of carbolic acid distilled from coal tar. This is being converted into picric acid. Benzol is also being used in large quantities for conversion into dinitrophenol from which picric acid is also being manufactured. Naphthalene and anthracene are free markets. The control of one of the chief primary products is, however, a heavy initial handicap on the output of coal-tar colours.

Since the commencement of the war I have been in a specially favoured position to diagnose what is passing in the minds of many colour consumers. One common thought which is very prevalent is, "We can understand you not being able to make some of the German specialities such as Indanthrene, Alizarin Sapphirole, etc., nor do we expect you to do so immediately, but we cannot understand you not being able to supply such old colours as Bismarck Brown, Benzopurpurine 4B, etc., the constitution and method of manufacture of which have been known for so many years." That is quite a reasonable attitude to adopt and my lecture will, I think, show completely the reason. Such colours are not being made freely at the present time, not through inability of British chemists to manufacture them but owing to the fact that the necessary products are not available, since they are required for more important processes.

The surplus of benzol and toluol which is set free by the Government after all their requirements for explosives purposes have been met, has a preferential call on it before it can be used for general colour manufacture. Next to explosives it is the first duty of the British coal tar colour industry to supply the various colours required for the varied equipments of the British, Colonial, and Allied Governments. People outside the trade have very little conception of the numerous colours required by the Governments; they vary from Mordant Brown and Sulphur Black down to Methyl Violet for typewriter ribbons and Soluble Blue for ink for the Stationery Office. The huge demand for khaki uniforms required by the military authorities for the equipment of the troops caused a corresponding demand for mordant yellow, brown, and green, blue, or black. The demand at the outset for these colours was overwhelming. Mordant Yellow was very scarce at the beginning, but the demand for this product has now been more than fully met. Seeing that salicylic acid is a constituent of all mordant yellows and is in turn derived from carbolic acid, you will readily understand why it was scarce. Mordant Brown never caused any difficulty as the supply was and is more than sufficient to meet all requirements. The supply of Mordant Green has also been very large. You may have seen in the scarce Press that the dyes being supplied by the British firms were not anything like as good as those of the German firms, but I wish to state most emphatically that khaki uniforms dyed with mordant yellows, browns, and greens of British manufacture are equally as fast to light, exposure, and wear as any similar cloth that was previously delivered to the British Government dyed with German colours. The British firms have every reason to be proud of their products for this purpose, and the day when it is necessary to stipulate German colours in British khaki specifications is past.

Sulphur yellows, browns, and blacks have also been supplied in very large quantities by the British firms for the cotton equipment of the armies such as cotton webbing, tropical uniforms, trench capes, ground sheets, etc., and here again the colours supplied have not been behind German colours for fastness to light, exposure, washing, etc. Not only have all the British requirements been met, but large quantities of British-made dyes have been used in Australian, Canadian, Belgian, French, Russian, Italian, and Serbian equipments. I do not give these facts as a handicap on the British industry, rather is it intensely proud of its achievements in this direction under such difficult conditions; but I do put it forward as a definite reason why many colours have not been made which would otherwise have been made had not the energies of the British chemists been so largely occupied in producing explosives and equipment colours.

Now let us examine a few of the products derived from benzol and toluol, which are so important for coal tar colour manufacture, and you will notice how the whole path is beset with a continuous demand for nitric and sulphuric acids. The primary step in the manufacture of coal-tar colours from benzol is to convert it into nitrobenzol. From nitrobenzol one proceeds to aniline oil and salts which have numerous uses. They are consumed in large quantities for the production of Aniline Black on the fibre both in dyeing and calico printing. Aniline oil has always been most extensively made in Great Britain, so that the shortage is not due to any lack of manufacturing experience but mainly due to shortage of acid. It

would be tedious to detail all the uses of aniline oil but it enters into the manufacture of numerous colours, including Acid Orange, acid blacks, acid reds, Magenta, soluble blues, nigrosines, and indulines, whilst in the form of dimethylaniline it is required for the important basic colours Auramine, Methyl Violet, Methylene Blue, and Malachite Green; it has also been largely supplied for munition purposes. *p*-Nitraniline is a very important derivative of aniline obtained with the aid of the inevitable nitric and sulphuric acids. It is consumed in large quantities for the production of Para Red by the cotton, calico printing, and paint trades, whilst it enters largely into the production of many important colours, including blacks; it is also extensively used for coupling on the fibre with suitable direct cotton colours; it is, in addition, the intermediate stage in the production of *p*-phenylenediamine, which is used in colour manufacture and by the fur trade for producing a black on furs. Aniline is also the starting point for phenylglycine, which is the primary product for one of the two processes used on the large scale for the production of synthetic indigo.

By the alkaline instead of the acid reduction of nitrobenzol, one arrives at benzidine, which is such an important base for the making of a large number of the popular direct cotton colours, such as blacks, blues, greens, violets, oranges, etc. Benzidine base has been made in this country in normal times, so that here again the present shortage is not due to the inability of British chemists to manufacture the product, but to inability to get a sufficiency of the necessary materials.

Another important product from benzol is dinitrobenzol, which is the starting point for *m*-nitraniline used in wool colours, and *m*-phenylenediamine. This latter product is of the utmost value in colour manufacture and enters into the constitution of numerous important colours such as:—

Mordant browns for wool which have been used in enormous quantities for military uniforms; sulphur browns for cottons, which have been extensively used in the dyeing of all cotton khaki equipments, such as tropical uniforms, cotton webbing, etc.; it is also required for direct cotton blacks and browns, Chrysoidine, and Bismarck Brown. You will therefore see that this product is in enormous demand, whilst it must not be forgotten that the production of the equipment colours must take precedence of all other colours. This is the explanation why such common colours as Bismarck Brown, Chrysoidine, and cotton blacks and browns are in such limited supply; again not due to the inexperience of British chemists but to lack of the necessary products.

Another product from benzol which is of the highest importance is dinitrophenol. This product is used in the manufacture of sulphur colours, which are consumed in enormous quantities in peace time and which have been used so largely in Government equipments. It is fortunate for the cotton trade in particular that the manufacture of this important intermediate product and of sulphur colours was so firmly established in this country prior to the war. I do not think it is an exaggeration to say that sulphur colours have been produced in larger bulk than any other class of colour since the war broke out. The production, huge as it has been, has not been enough to satisfy the legitimate requirements of the trade, but here again the shortage has not been due to lack of experience or plant, but solely to lack of material and labour.

It is fortunate for this country that the manufacture of dinitrophenol was firmly established, because it has been used in an alternative process for the manufacture of picric acid other than direct from phenol; it has therefore increased the production whilst easing the pressure for synthetic phenol.

The amount of phenol distilled from coal tar being utterly inadequate for the amount of picric acid required by the authorities, large quantities have had to be made synthetically by caustic fusion of sodium benzene-monosulphonate.

Carbolic acid plays a most important part in colour manufacture and the shortage of this product has been a very great handicap to the colour industry. Phenol enters directly into many colours, and is one of the generators of Chrysophenine, the direct cotton yellow which is so largely used and has been so badly missed.

o-Nitrophenol, which on methylation and alkaline reduction yields dianisidine, is another important derivative of phenol because dianisidine is the base for Cotton Sky Blue, the absence of which has caused much inconvenience to cotton dyers and has caused famine prices to have been paid for any existing stocks of this colour.

Salicylic acid is another important derivative of phenol both from a medicinal and a colour point of view. It was not made in this country prior to the war, but its manufacture is now firmly established. It is largely used both medicinally and in the manufacture of colours of the highest importance, including fast chrome blacks, reds, oranges, and yellows, also direct cotton reds and greens. The great shortage of these colours has been influenced by the scarcity of this product due to the phenol being required for the manufacture of explosives.

The other derivatives of benzol which I propose to mention are resorcinol, made by the caustic fusion of benzenedisulphonic acid; this product enters into the constitution of many direct cotton colours and also colours of the Rhodamin class; another derivative is chlorobenzol from which are derived some of the fastest chrome colours for wool extant, amongst which may be mentioned the fast chrome blacks which are fast to potting.

In the manufacture of picric acid for explosives purposes it is inevitable that some is produced which will not pass the Government specifications. This is liberated by the Government for the purposes of colour manufacture. For the last fifteen years picric acid has played an important part in colour manufacture.

Toluol is of vital importance as a starting point for colour manufacture, and the restrictions on its use are responsible for the lack of many colours which are absolutely essential for the dyeing trades. *Ortho-* and *para*-nitrotoluol are obtained by direct nitration of toluol. From *o*-nitrotoluol tolidine base is obtained by alkaline reduction, and from it are made many direct cotton colours of large consumption. I will content myself with mentioning one, viz.:— Benzopurpurine 4B. This is the reason why such a common and popular colour is not being made at the present time.

There has been a great dearth of direct cotton yellows in the colour market, but the reason is very simple. In peace times there were three main classes of direct cotton yellows used, viz.:—

1. Chrysophenine, which is made from diaminostilbenedisulphonic acid (a toluol derivative) coupled with two molecules of phenol and the product ethylated; both the products are required for explosives, hence no Chrysophenine.
2. Primuline and the fastest class of Direct Cotton Yellow which are derived from dehydrothio-*p*-toluidine; these require *p*-toluidine.
3. The Sun Yellow or Stilbene Yellow class which require *p*-nitrotoluol for their manufacture.

The direct cotton yellows form an excellent example of the handicap imposed on the coal tar colour industry by the diversion of toluol for

explosive manufacture. The last two classes of yellow have always been extensively made in Great Britain so here again the plant and experience is available but not the material.

Toluol derivatives are also required for the manufacture of sulphur blues and greens; this accounts for the limited supplies available, which are insufficient to meet the legitimate demands of the trade. Toluidine also enters into the manufacture of Magenta and Safranine which are so largely used in the paper trade amongst others, whilst Rosaniline is also required for the manufacture of Soluble Blue so keenly desired by the shoddy trade. Here again the experienced chemists and the plant are available for all these colours which were made in Great Britain in peace times but the material is now lacking.

Dinitrotoluol leads to *m*-toluylenediamine, which is so largely used as a developer for diazotised cotton blacks and as a component of direct cotton oranges and blacks.

Among the other derivatives of toluene which find extensive application are benzyl chloride, benzaldehyde, and ethyl- and methyl-benzylanilines.

I now pass on to the last mother product with which I propose to deal, viz., naphthalene.

The uses of naphthalene in colour manufacture are multitudinous, but I only propose to deal with those derivatives of major importance. Naphthalene has no limiting restrictions on its sale like benzol and toluol.

Naphthalene has four primary derivatives, viz., α- and β-naphthylamine and α- and β-naphthol, of which the α-naphthylamine and β-naphthol are the more important. α-Naphthylamine has always been largely made in this country. β-Naphthol used to be made in this country but was not being manufactured on the outbreak of war. The manufacture has now been resumed and there are several naphthol plants on various scales working in this country at the present time.

α-Naphthylamine is a most important constituent of acid blacks, chrome blacks, and sulphoncyanines—all three classes of colour of enormous bulk consumption.

Naphthionic acid, the 1.4-monosulphonic acid of α-naphthylamine, is largely used in the production of reds, both acid and direct cotton reds; it enters into the constitution of Benzopurpurine 4B. Neville and Winther acid, the 1·4-monosulphonic acid of α-naphthol, is also of considerable importance in the manufacture of acid reds and direct cotton blues.

β-Naphthol is itself used to an enormous extent in what are known as the insoluble azo or ice colours such as Para Red, Naphthylamine Claret, etc., whilst it is also largely used as a developer for the ingrain colours on cotton.

The manufacture of large quantities of naphthalene derivatives is not limited by any shortage of naphthalene, but it is seriously limited by the shortage of sulphuric and nitric acids.

The following four acids of the highest importance require fuming acid in their commercial production.

H acid. Aminonaphtholdisulphonic acid 1:8:3:6: used in acid blacks, cotton blacks, cotton navies, and cotton blues.

Chromotrope acid. Dihydroxynaphthalenedisulphonic acid 1:8:3:6: used in producing a full range of acid reds of easy levelling powers and good fastness to light which by treatment with bichrome are turned to fast navy blues.

Gamma acid. Aminonaphtholsulphonic acid 2:8:6: used very largely in direct cotton colours, notably the "BH" class of blacks.

Aminonaphtholdisulphonic acid 1:8:2:4: used in the production of bright blues.

The following important acids do not require fuming acid but may be made with ordinary sulphuric acid.

Phenyl peri acid. Phenyl-α-naphthylamine-δ-sulphonic acid: used for sulphocyanines.

G salt. β-naphtholdisulphonic acid 2:6:8:	used for scarlets, bordeaux, etc.
R salt. β-naphtholdisulphonic acid 2:3:6	

I have not touched on anthracene and the alizarin and vat colours, the manufacture of which has not up to now been developed in this country except the manufacture of Alizarin Orange, Red, and Blue. Here nature has imposed an additional handicap on development, due to the fact that practically all the bromine originates in Germany. Bromine is largely used in this branch of colour manufacture.

I have now finished what must have appeared to many but a mere catalogue. However I have felt it necessary to show the large number of products which are required in the coal tar colour industry before a start can be made with colour, and to give an adequate idea of the handicaps which the state of war has imposed on the coal tar colour industry. The shortage of acid in this country is in course of being rectified, and there is no after effect of the war which may be prophesied with more certainty than that there will be an abundant supply of acids in peace time. Plant for the manufacture of colour on a scale never hitherto attempted in Great Britain is being erected as fast as is humanly possible. Research also is being organised on a scale hitherto not attempted, so that the neglect of research may not in future be counted against the British firms as one of their sins of omission. In fact when the colour consumers of this country come to weigh the efforts which have been made for them by the staffs of the colour firms of this country—from the directors down to the humblest colour tester—they will, I think, be amazed at the success of those efforts. The present time does not allow of this to be done because calm judgment cannot be formed when the minds of the consumers are distracted by the shortness of supplies. It may be of interest to mention that it has been necessary in Germany to advertise for *p*-nitraniline in the technical journals, which shows that colour supplies in Germany are far from normal.

The task before the British industry is inestimably difficult because you will no doubt be aware the Germans have formed a huge combination with eleven millions pounds sterling capital to fight the British efforts, which at first they treated with contempt. On what lines the Germans will be allowed to compete, the future will decide. This opposition is most formidable, formed as it is of the great German colour firms with forty years experience behind them. Nevertheless the British chemist is being given a chance for the first time to fight the German chemist with anything like equality of opportunity. Speaking for my own colleagues, we welcome the fight in order to show that British chemists are equal to German chemists. I have little doubt but that the other chemists engaged with other firms do so likewise.

The fight will be a stiff one—none know this better than those few British chemists who battled against the Germans in peace times. In the past the British firms fought in a very antagonistic atmosphere; in this respect some scientific societies were not entirely free from blame. Let us have a sympathetic atmosphere in future; let authors who read papers on colours illustrate their experiments with British colours. They will find samples just as readily furnished by British firms as by German firms. What the British industry requires is sympathy and patience—the handicap of forty years is sufficiently heavy to warrant consideration. If we must have criticism do not let it be destructive criticism—anyone can

furnish that—but let it be constructive criticism founded on knowledge.

DISCUSSION.

The PRESIDENT said that the paper was to be regarded as being an authoritative answer to the criticisms which had from time to time been levelled at the organisation responsible for making up our dye deficiencies. It was interesting to learn that the difficulties with which the manufacturers were confronted did not arise from their lack of knowledge or from their want of skill, but almost entirely from the fact that the primary products, the coal tar distillates, were required for the purposes of the Army and Navy.

Mr. H. N. MORRIS said that no reference had been made to the valuable assistance that had been given this country in the supply of dyes by the Swiss manufacturers. He suggested that something more might be done in the way of co-operation with the Swiss manufacturers, who had had so much more experience than we had in this industry. We could not expect forty years' experience to be acquired in one or two years. Mr. Whittaker had referred almost exclusively to the German competition, but he pointed out that after the war we should have very serious competition from America, and possibly from Japan. American manufacturers had been able to take full advantage of the shortage of colours and intermediate products in this country and had been free from war taxation. Some of them had been, and were still writing off out of the extraordinary profits made out of consumers in this country, all their capital expenditure, so that they would be in a very strong position as compared with our manufacturers. Mr. Whittaker had referred to very valuable work done in synthetic dyes such as Bismarck Brown, Chrysoidine, Indulines, etc.; it was true these colours were being used in large quantities, but he suggested these would not be permanent products. Nowadays consumers would use any dyestuffs they could obtain. These were not the colours that the Germans made a profit out of; their large profits were made out of patented colours. What would be the position at the conclusion of the war with regard to all the patents for the best of the colours? When the patented colours come on to the market again they would be in great demand, and most of the colours now being made would be almost unsaleable. Immediately after the outbreak of the war it had been proposed to our Government that if they would grant the use of all enemy patents in this country, either free or with a reasonable royalty for the duration of the war, and for a certain period after the war, the manufacturers in this country would lay down plant and put capital into the industry, and there would be no need of any Government subsidies. This proposal had not been adopted. He agreed with Mr. Whittaker that German chemists were not better than University trained British chemists: their only advantage was that they would work for a much lower salary. The question of intermediate products was of the highest importance, and co-operation among manufacturers of these products would be necessary to prevent over-production. Unless we had adequate organisation and co-operation between manufacturers both of colours and of intermediate products, and unless we had more equitable arrangements with regard to patents, we were in danger of losing the industry again after the war.

Mr. W. P. THOMPSON said that a licence could be obtained to work enemy inventions patented in England by applying to the Board of Trade. He had done so in a number of cases and thought there was no difficulty. Further, it was invariably understood that those licences were to continue practically for the life of the patent afterwards, so that there need be no fear that a license would end when the war ceased.

Mr. A. G. BLOXAM said that the present position was that the licence was to last until the end of the war and then, if necessary, it was to be reconsidered with the view to adjusting any question of royalty as might seem fair between the parties, but that condition, as he understood it, would depend upon the behaviour of Germany with regard to German patents owned by Britishers. If Germany would not adopt the same attitude and continue the licence on what was determined to be a fair royalty, the British Patent Office would refuse to reconsider the licence, which would therefore continue throughout the life of the patent.

Mr. W. P. THOMPSON thought there was no doubt that when the time came the question would be not as to whether the Germans would reciprocate, but whether the English would reciprocate.

Dr. A. REE disagreed with the remarks made by Mr. Thompson. One of the principal reasons why our industry in aniline dyes and similar products had suffered was the fact that our patent laws had favoured Germany rather than this country. From the beginning some of the ablest of our patent agents and some of the most eminent of our lawyers had been specially retained by German firms to help them. We had suffered from that for a great many years, and he was very sorry that, under present conditions, after the experience they had had since the war began, Mr. Thompson should make a statement which he considered to be contrary to fact, viz., that our Patent Office had been the reverse of conciliatory and that Germany, on the contrary, had done everything to try and meet us. At the time of the agitation which the Manchester Chamber of Commerce had conducted for many years, they had an amount of opposition on the part of certain professional elements which had done an infinite amount of harm to this country. If they had been able to carry out the proposals made by Manchester some 15 or 20 years ago he was certain that many of the difficulties they had met with since the war broke out in regard to the supply of colours, high explosives, etc., could have been avoided. Compulsory working would have been the best way of dealing with the situation. Alternatively he was satisfied that, if we had followed the example of Switzerland 30 or 40 years ago and granted no chemical patents, it would have been the best thing for this country. The Swiss in the early days of the aniline colour industry had been helped very much by the fact that they were able to use any inventions without paying royalty. He understood that it had been largely owing to pressure brought by the German Government on the Swiss Government that the Swiss had finally introduced a patent law.

Mr. R. D. PULLAR said that, as a member of the Users Committee which had had a good deal to do with the Government action in promoting British Dyes, Ltd., every possible method of doing this was most fully and carefully considered. The proposal about patents did not come before that Committee, but every suggestion brought before the Committee had been most carefully considered. The question of dye patents was only a very small part of the proposals for protection which had been brought before the British Government. It had been said that dye manufacture was a key industry, and ought to be treated as an exception to the ordinarily accepted policy of the Government, but it was necessary to take a wider view than that. It was impossible to protect the dye industry by itself. Had that been done, there would have been a number of other industries

asking for similar privileges, and that would have been a difficult situation in view of the many complicated questions arising out of the war. It seemed to him that if British chemists and British dyers could not proceed on excellence they could not proceed at all. As a user he would be only too glad and too willing to give every possible preference to British dyes, but a mere tariff to shut out German dyes would not, in his opinion, produce the desired result. It would only give rise to a series of complications and difficulties which were not now foreseen. If British colour manufacturers got a fair field and no favour they would be able to hold their own at least. It ought to be generally known that British dyes had actually been sold in Germany previous to the war. Complaints had been made about the quality of dyes that had been issued to the trade by certain British firms; he thought it was not fair in war time to expect the exact standards which had been a feature of imported colours.

Mr. W. F. Cooper asked what was going to happen to British Dyes, Ltd., after the war. What safeguard had they that after the war they would be able to continue—at least without a considerable subsidy from the Government? There was also the question of the supply of bromine. The Germans had the power to make such regulations as they liked with regard to the supply of potash or bromine.

Mr. J. K. Hill said that if we were successful in the war we could make terms one of which might be to impose a tax on German industry.

Mr. Fryer said that German and Swiss manufacturers took a great deal of pains to find the exact tint necessary in each industry, whereas in the past their experience had been that the British colour makers had only offered a certain standard product. Continental producers would send a range of 10 or 15 samples, with a notification that if they did not suit they would be prepared to go further into the subject, and if a sample of the raw material were submitted they would find out the most suitable dye for it.

The President said that one of the most important matters with which the Association of Chemical Manufacturers would have to deal would be the mutual arrangement of the manufacture of intermediate products and others of a similar character. The suggestion of Mr. Morris was an appropriate and practical one. It would be necessary to decide which were the firms that in respect of plant and other advantages were in the best position to make these intermediates economically. They would have to be encouraged to manufacture in competition with the cheap supplies coming from elsewhere, and that elsewhere, as Mr. Morris pointed out, was not only Germany. One large firm of colour makers had just recently made arrangements to establish themselves in Switzerland. He did not see how cases of that kind were to be met, where an industry was established in a friendly country.

Mr. Whittaker, in reply, expressed the opinion that co-operation would lead to the formation of trusts. It was not through any oversight that he had not mentioned the Swiss manufacturers, but his subject was the difficulties of the British coal tar colour industry. It was the simple colours, to which Mr. Morris had referred, that the trade wanted now; these colours had a very large consumption and were not patented. He was inclined to support Dr. Ree on the subject of patents. He had had experience of the difficulties and obstacles put in one's way by the German Patent Office. They referred one to references in books about fifty years old and they said the invention was covered by subjects which seemed to bear no relation to the dye. The service of British colour firms had been criticised to their detriment as compared with others. His own experience had been that many firms had given preference to the foreign manufacturers, but they hoped that after the war that would be different.

THE PRODUCTION OF ALKALOIDS AS AFFECTED BY THE WAR.

BY D. B. DOTT.

For some time after the outbreak of hostilities, alkaloids and other fine chemicals which were chiefly produced in Germany found their way into the United Kingdom, through the neutral countries, including America. Switzerland, which does a considerable manufacturing business of her own, is in a favourable position for sending into Italy things which have really been produced in Germany. By this time, no doubt, such indirect importation has been reduced to a minimum and we are mainly dependent on what we make ourselves, or import from allied or friendly countries. The conspicuous effect of the war on the production of alkaloids in this country, has been to greatly increase the demand for, and therefore as far as possible the output of, those articles which British manufacturers were already producing. Presumably the same holds true of manufacturers in allied and neutral countries. This increase has been mainly caused by the exclusion of Germany as a source of supply. Although Britain has for long been a producer of opium alkaloids and quinine, and more lately of caffeine, strychnine, emetine, and veratrine, Germany has been a larger manufacturer of all these bases, except morphine, while the preparation of atropine and most of the rarer alkaloids has been almost entirely in German hands. But the medical requirements of the Army are also responsible for the increased demand. Comparing the prices of alkaloids in May, 1914, with those of May, 1916, we find a rise in every instance, varying from 63% in the case of morphine hydrochloride to 700% in the case of atropine sulphate, the average increase of price in eight of the more important alkaloids being 237%. Atropine has scarcely been made in appreciable quantity in this country, and Belladonna root is scarce and dear. It has been reported that the *Hyoscyamus muticus* grown in Egypt and India yields 1% of alkaloid and over. If a sufficient supply of that drug could be imported, it would be an additional inducement to British manufacturers to take up the preparation of atropine. On the other hand there is no scarcity of opium, or of cinchona bark, or of nux vomica. It is only in a few instances that there is difficulty in getting the raw material. The use of emetine has greatly increased of late, a fact which is explained by the extended administration of the alkaloid for treatment of dysentery. The war is responsible for the rise in cost of freights, and for the enhanced price of many of the necessary solvents, the Government having commandeered or limited the supply of several of the latter. These are among the causes of increased prices.

According to the best information available, the making of alkaloids in this country, which were formerly made almost exclusively in Germany, has not as yet attained considerable proportions. Manufacturers are fully occupied with supplying the increased demand for their standard products. With a reduced staff and a limited supply of labour, the conditions are not favourable for embarking on new processes. The difficulty in obtaining delivery of newly-devised plant is another obstacle. At the same time, there is doubtless a good deal of laboratory work being done with the purpose of taking up the preparation of alkaloids and other compounds as soon as conveniently practicable. In the near future,

many compounds which we have been accustomed to import from abroad, will be prepared in British works.

It has been suggested, and the matter has been discussed in some of the journals, that we ought to do more in the way of growing medicinal plants in this island. I believe many individuals have been making private experiments in their own gardens, but nothing of an extensive nature has yet been done. Our climate and soil do not seem to be well suited for almost any of the alkaloid-yielding plants.

Seeing that some of the alkaloids have been synthesised, it naturally occurs to one that the present time would be very favourable for the production of such of those as are in brisk demand. With atropine selling at 170 shillings an ounce and cocaine at 23 shillings, the time seems opportune for the artificial preparation of these bases, should a practical working process be known. It is an interesting fact that there is no such synthetic alkaloid in the market. There are evidently difficulties connected with the complexity of the process, expense of materials, or the poverty of the yield, which prevent the published methods giving remunerative results. If the artificial production of those highly-priced alkaloids cannot be made a financial success, it seems very unlikely that morphine and quinine, with their more complicated structures, and much lower prices, could ever be produced at a paying cost, even should the secret of their synthesis be discovered. Notwithstanding much elaborate and ingenious research the synthesis of the two most important alkaloids remains still unaccomplished. But while the synthetic preparation of the natural alkaloids remains a matter of academic interest, useful results have been obtained in the discovery of substitutes having a comparable if not equal pharmacological value. Thus the phenylglycolyl ester of methylvinyldiacetonalkamine is used as substitute for atropine under the name euphthalmine, and has a strong mydriatic action. Cocaine is the benzoylmethyl ester of ecgonine. Hydroxy-acids having a similar constitution to ecgonine having been prepared, it is found that when converted into benzoylmethyl compounds, they produce local anæsthesia like cocaine, and are known as eucaines. One of these is the benzoyl ester of vinyldiacetonalkamine. It is the lactate of this base which the Pharmacopœia includes as benzamine lactate. But the synthetic anæsthetic which is proving of most general value is novocaine (*p*-aminobenzoyldiethylamino-ethanol hydrochloride). Scarcity of any of the natural alkaloids must tend to increase the use of synthetic substitutes, if they are at all comparable in action. Wherefore one effect of the war is to act as an indirect stimulus to the production of artificial alkaloids.

THE MANUFACTURE OF SYNTHETIC MEDICINAL CHEMICALS AS AFFECTED BY THE WAR.

BY FRANCIS H. CARR.

For two years now we frequently have been met by the question "Why do we not manufacture this or that in England ?"; and in no other section of the wide field of Industrial Chemistry has the question been as persistently or as pertinently asked as in that of Synthetic Organic Drugs. Although it is not my intention to attempt to deal with the answers given to this question, nor should I expect the members to bear with me if I did, it may be recorded to the credit of English chemists that even in the case of very complex organic compounds they have rarely, if ever, replied with a *non possumus*.

It is, of course, incorrect to suppose, as many have done, that no synthetic organic drugs were manufactured in this country before the war. One might mention the names of firms who were already doing important business on these lines; chiefly, however, these firms manufactured drugs required in small quantities, and in the selling of which there happened to be little or no competition. Of the important drugs which were not manufactured here one may enumerate the following :—antipyrin, aspirin, salicylic acid, phenacetin, chloral hydrate, salol, phenolphthalein, saccharin, veronal, sulphonal, trional, eucaine, and novocaine. When we consider that the total imports of products of this class amounted then to the value of over a million pounds annually, we must admit that we were doing a very small proportion of business in this country.

When war broke out the situation was by no means easy, but its necessities evoked an energetic response. Many difficulties have been encountered such as that of obtaining a sufficient number of trained men, both chemists and engineers, that of procuring plant, and above all the fact that in practically all large concerns the works organisation has been employed at least in part in making supplies peculiar to the needs of the war. In view of these disabilities the achievements have been both remarkable and substantial. In many instances manufacturers, assisted by high prices, have not only produced the substances required, but have done so in good yield and of good quality. But this fact alone is not sufficient to argue the case for any established commercial success, because in many instances it is necessary for such success that the by-product of some other chemical manufacture should be available at a low cost, and this other manufacture is not yet in all cases established here.

Also, intermediate products which are required in larger amounts for other manufactures, particularly dyes and photographic chemicals, are required for synthetic drugs in smaller quantities. Economic manufacture will only be established in such instances when these intermediates are produced on a larger scale for all consumers.

Notwithstanding these aspects, we may say that an industry already developing before the war has since grown to considerable proportions. Organic antiseptics, antipyretics, sedatives, local anæsthetics, and diuretics of purely English manufacture are now available to medical men. How great the need of them was, is proved by the extraordinarily high prices which have ruled.

The time is not ripe for entering into details of the exact extent of the present development; at least we know that it is substantial, giving evidence of great vitality, and that for its own sake as an industry, as well as for reasons of British national independence, it must be proceeded with and preserved. Nevertheless, the development has been that of an exotic, and we are confronted with the problem of deciding by what hardening process the new growth can be rendered suitable for the free air of an open market.

It is axiomatic that an industry requiring so much skill on the part of its workers, so much experience in direction, and so much perfection in machinery and detail, will need in the beginning very careful attention before being turned into the playground among the bullies of competition; but it must be fitted for this playground as soon as possible, and when it gets there we must ensure that the prefects take every care to secure the newcomer fair play.

Germany's huge sugar industry was built up largely as a result of war, on account of Napoleon's edict closing ports to British products. It was fed by State subsidies from the time of Frederick the Great. We cannot help reflecting how invaluable the ability to manufacture sugar has been to Germany in this war, quite apart from its economic value.

Is it too much to believe that of very much greater importance to the State will become the synthetic organic industry of the future? If we but consider the progress of synthetic chemistry during the past half century in conjunction with such achievements as the large scale production of synthetic ammonia, indigo, and caffeine, the imagination is filled with pictures of the potentiality which awaits the organic industry of the future.

We chemists know that the power we are to-day fighting in Germany is largely chemical power. Convincing proof of this will be available when, after the war, we shall be enabled publicly to demonstrate the almost incredible extent to which chemical science has played a part in both offensive and defensive warfare, as well as in the supply of the necessaries of life. The perils to which our initial technical inferiority to Germany exposed us should surely carry conviction to the rulers of this nation. It will not do so unless assisted on our part by the reiterated expression of our faith. The public memory is apt to be short, and it may readily be forgotten how profoundly we were affected at the outbreak of war by our dependence on external sources for supplies of organic medicinal chemicals.

Even though medical science is as yet merely in the earliest stage of its development, it is in a large measure reliant upon synthetic chemicals for the relief of pain and for the cure and prevention of disease, as well as in surgical treatment. The substance salvarsan affords a powerful illustration of our dependence upon Germany before this war.

Syphilis is a scourge following in the wake of every war, and salvarsan is the drug of greatest importance in its treatment. Except for the immediate intervention of Messrs. Burroughs Wellcome and Co., in England, and of Messrs. Poulenc Frères, in France, the Allies would have been at a great disadvantage in having no supply of this potent remedy. Yet, important though chemical science is to-day in the treatment of disease, its present importance is not comparable with that which awaits it when pharmacology has advanced but a few steps further. Our industries must keep pace with these advances. No longer can we be satisfied to be externally dependent for supplies of vital importance. The war has—not too soon—removed the scales from our eyes.

The opportunity is unique. Great Britain, the home of coal-tar and the birthplace of cheimcal industry, is at least as favourably situated as any country for the manufacture of organic chemicals. Furthermore, if given time, the industry can be established upon a basis of complete independence suitable for the conditions of free trade. But it is our duty to admit frankly to-day that some form of protection is of vital necessity during the coming ten years, while we develop a complete organisation and rectify educational shortcomings. Without this protection, what has already been accomplished will rapidly and completely be demolished by competition from abroad. There can be no doubt that the industry unprotected would become the butt of German heavy artillery, and would suffer even greater damage than did dyes, glass, chlorine, etc., before the war.

The recent announcements of the combination of all leading German chemical works will not have escaped attention—a declaration of war on the chemical manufacturers of this and the allied countries is definite and unmistakable. Enough is known of German methods to make it obvious that for no object will German industry and organisation, directed from the highest quarter, and financed from the nation's purse, be more ruthlessly employed after the war than to recover, consolidate, and extend the hold formerly possessed over the world's chemical industries.

In fact the successful prosecution of this object will be recognised by our enemies to be one of greater material importance than the recovery of her lost colonies and European territory.

Important though protection is, nothing is more certain than that without similar combination, organisation, and national assistance no form of protection will, by itself, enable the British chemical industry to hold its position in the world's markets and eventually in its own.

No opportunity should be lost of impressing upon the nation and its rulers the fact that the possession of a powerful and self-contained chemical industry is of the same degree of importance as that of a great engineering industry has proved to be.

We must not content ourselves with educational reforms and grants in aid of research, desirable though they are, alone they will avail nothing. Our conservatism, as a nation, affects the question doubly, for our capitalists and bankers have little ability to face failures without rebuff and discouragement, while at the same time we require the pressure of necessity, such as arises from prohibiting imports, to make us enter into new competitive undertakings. An illustration of this was afforded by attempts which were made many years ago to establish the synthetic production of camphor in this country. Preliminary plants were erected, and good and capable men were managing them. Initial difficulties were, of course, encountered—what chemical venture, indeed, can be without them? Considerable quantities of excellent camphor were sold for pharmaceutical and manufacturing purposes; nevertheless after a comparatively short time, and long before the merest suggestion of technical failure should have been entertained, the drop in the price of camphor which foreign manufacturers aimed as a blow at the new industry put fear into the hearts of those responsible for it. It was then abandoned with serious loss of money to those pioneers to whom, in a happier issue, we should have been as a nation indebted. Had the State then realised, even as well as it does to-day, that its ultimate prosperity depends upon the application of science to practical ends, surely such an undertaking would not have been allowed to be dropped until it was finally proved to be valueless. Having accomplished its purpose, it is easy for a combination such as that which dumped camphor at a low price more than to recover losses by subsequently raising the price.

It may be anticipated that German competitors will adopt a variety of skilful manœuvres to combat the new developments in this country, such as charging high prices for intermediate products, offering low terms for finished products on long period contracts, systematic dumping, etc.

Surely there is no more urgent requirement of the Association of Chemical Manufacturers than that it should bring together the smallest and largest workers in this field frankly to discuss the measures to be taken to ensure their future progress; and that it should bring such influence to bear upon the Government, either directly or through the Board of Trade, as will secure the necessary legislation. It must here be said that the absence from amongst the Board of Trade committees, dealing with post-war problems, of any to deal with the chemical industries is of ominous import. Never was the need of a united chemical " voice " more imperative than now.

An immediate decision to extend for a period after the declaration of peace the prohibition against the importation of German chemicals would have a far-reaching effect by giving confidence to capitalist enterprise. It would also give time for the State Policy affecting our future fiscal relationship with Germany to develop before any

tariff protection is adopted. There is already evidence of internal competition sufficient to make healthy rivalry and to ensure that prices will drop to a reasonable level, though the high prices which have ruled are the less to be regretted because they have brought a flow of capital into the industry.

No doubt prohibition of long standing would bring about stagnation and do damage to certain trades, but it does not follow that an extension of the *status quo* for a fixed time would not be of great advantage. Medicinal drugs are not raw materials in any proper sense of the word, and high prices of drugs at least have the advantage of deterring the public from consuming too much of some of them.

Should any tariff be imposed the money derived therefrom ought to be devoted exclusively to research and education. Above all, any protective measures must be framed with the knowledge that scientific efficiency in production will determine in the long run which nation shall be strongest, and therefore an industry protected during its growth must be in a position ultimately to support itself unhelped.

Technologists must rely upon efficiency and not sympathy. After all, the extent to which official sympathy and financial aid will be forthcoming will be largely determined by the evidence the units of the industry give of their ability and determination to organise and co-operate. Detailed statistical information will be required regarding the nature and quantity of German pre-war exports to this and other countries, so that the extent of the ground to be covered can be approximately ascertained. Representatives of each branch of chemical industry must define the extent of their requirements from other branches, which in their turn must co-operate.

We look to the Association of Chemical Manufacturers to take the lead in these matters and to set afoot the necessary organisation to prevent overlapping and gaps, to arrange by mutual concessions that too many do not manufacture the same chemicals, and to secure the manufacture of those chemicals not already provided for. A further function of the Association will be to call upon certain branches of chemical manufacture to supply those raw materials, such as sulphuric anhydride, chlorsulphonic acid, carbonyl chloride, phenylhydrazine, acetoacetic ester, phosphorus pentachloride, etc., even though—on account of the smallness of the quantities at first demanded—such undertakings could be regarded as business propositions only by those far sighted observers whose motives are tempered by regard for the chemical industry as a whole.

Similar co-operation with the dyemakers in regard to the manufacture of intermediate products is imperative. Take, for example, the manufacture of ortho- and para-aminophenol—possible starting points for a great number of synthetic chemicals—or one might mention dimethylaniline, dimethyl sulphate, β-naphthol, phthalic anhydride, and so on. If we all continue merely to fulfil our own requirements of all these products, we shall find ourselves on the rocks. Such substances are required by the makers of dyes, drugs, and photographic chemicals, and they can, of course, be made with much greater economy on the large than on the small scale.

We must organise in a new spirit—not driven thereto by the greed for personal gain or because we wish slavishly to copy Germany, but because of the strength it gives; and we must be willing to give and to receive assistance with a view to national economy. Unless we can marshal our forces to effect this economy we cannot enter into competition with countries thus organised, nor will Great Britain worthily retain her supremacy among the nations unless her manufacturers prepare to carry on the business of production by combining, where necessary, to secure such economy.

Whether or not the manufacture of synthetic drugs will develop to a large industry able to hold its own in the world's markets, will be determined by the dye industry. For the demand for synthetic drugs, as well as for artificial perfumes and photographic chemicals, is small by comparison, and their manufactures bear a relation to the dye industry somewhat similar to that which the latter bears to the coal tar industry. With a large dye industry the supply of intermediates would be assured.

At the conclusion of war the new coke oven plants that have been established will, we hope, be available to supply immense quantities of by-products, and means must be adopted to prevent them being too largely exported. Now, we need immediately to organise our means of converting these by-products to intermediates for the use of the whole country. There surely will be factories in plenty as well as suitable workers from our high explosive plants whose experience will fit them well for such operations as sulphonation, nitration, and reduction on the large scale. What a golden opportunity it appears to be.

It may be regarded as outside the scope of this paper to deal with the scheme of industrial research which is administered by the Special Committee of the Privy Council; there must be already an immense number of important investigations for which the Committee is providing. Nevertheless, so badly are we placed in this country with regard to supplies of cheap alcohols, acetone, and acetic acid, and so important are these to this country in time of war and to the branch of industry in question at all times, that the hope is expressed that some action will be taken (if it has not been done already) to promote industrial research in these connections.

Cheap and pure methyl and ethyl alcohols lie at the very foundation of fine chemical manufacture. No one other obstacle has barred our progress in this industry so much as the Government restrictions on their use. Mr. Thomas Tyrer, to whom for his classic work on this subject we are all immensely indebted, has put the case so forcibly and well that in recent years we have been disposed to adopt a *laissez faire* attitude in this matter because there is so little new to be said. Such an attitude, correct in scientific matters, is unfortunately apt to be misinterpreted by the official mind to mean that our grievance is assuaged. Such is far from the case.

Alike as solvents and for their use in the synthesis of organic compounds, both methyl and ethyl alcohols are daily necessities and must be used in large quantities. The restrictions make industrial methylated alcohol dear, while the impurities added for methylating purposes are a constant source of trouble in decomposing one's product, and giving objectionable residual substances; we are consequently not only put to a disadvantage as regards cost, but also as regards quality of our manufactures.

If the authorities will remove the duty from pure methyl alcohol (or shall we call it carbinol, to obviate official confusion), and allow pure methyl alcohol to be used in methylating—and it is an effective ear-mark—nearly all difficulties will be overcome. It is difficult to see how the revenue could be appreciably affected by the change, especially if a system of inspection by men of chemical knowledge were adopted at the same time.

The procedure in factories concerned with the manufacture of synthetic drugs differs from that in most other factories because of the intermittent or discontinuous nature of the work. The same worker may not be engaged on the same operation for many weeks or even days in a year, and conse-

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quently that "rule of thumb" knowledge, so invaluable in other cases, is less to be relied upon here.

Great care and attention to detail are called for, even on the part of those workers who have no useful knowledge of chemistry, and serious losses may occur from want of care. These circumstances lead me to call attention to an aspect of the education question, which has attracted less notice than some others. The type of worker required may be compared to a city clerk, a knowledge of physics and handicraft taking the place of shorthand and typewriting. Reference to the matter here is justified only by the fact that workers of this skilled type would be of the greatest assistance to most other industries. A great national need exists, and is felt particularly in our work, of a better product from our primary and secondary schools. Much can be done by improving the curriculum in them and by extending the leaving age. Is it not possible that compulsory attendance at continuation schools for 8 hours a week up to 18 years of age may be enacted in this country immediately after the end of the war? I would further propose that employers work youths of this age for correspondingly less hours. We have in this country many institutions at which the attendance is scandalously small; to what extent they would provide the necessary accommodation others must decide. The deduction to be made is that for the establishment of efficiency in all works, and in particular those dealing with such a large variety of products requiring care, judgment and attention to detail, as is the case in the manufacture of synthetic drugs, it is of the utmost importance to have a better supply of workers of great diligence and capacity for understanding. While the training of such men must inevitably be done in part in the factory, the factory is not the school and cannot take its place. Intimately connected with this question of the personnel of the workers in our factories is that of the remuneration and prospects offered to those engaged in them—a large subject, on which time does not now permit me to dwell.

I conclude with an expression of hope that those concerned in the manufacture of synthetic drugs may rapidly progress in friendly relation with one another until the day when they will be able to compete fairly and squarely in the world's markets.

THE MANUFACTURE OF FINE CHEMICALS IN RELATION TO BRITISH CHEMICAL INDUSTRY.

BY C. A. HILL AND T. D. MORSON.

The fine chemical industry, owing to the widely distributed nature of its products, is no bad example of the importance of chemical industry as a whole to the community at large. It provides medicines needed for the health of the civil population, and necessary for the conduct of the war, both for the treatment of the wounded and for maintaining the health, and therefore the efficiency, of the fighting men. It provides reagents necessary in Universities, schools, research laboratories, private analytical laboratories, and those of munition works, where the testing of explosives is only one out of innumerable instances which might be cited. The ramifications of the fine chemical industry, and the dependence of other industries upon it, are intricate and far-reaching.

The problems to be solved in, and the salient factors governing, the manufacture of fine chemicals, differ markedly from those affecting heavy chemical manufacture. In the case of the latter the supply of "raw" materials, which frequently occur naturally, the transport and freight of both the "raw" materials and the manufactured products, cost of fuel, power and large plant, are all-important; in the former, on the other hand, the cost of labour is often only a small percentage of the total cost of production; in fact, the prices of the articles manufactured are usually so high that transport and fuel problems become relatively insignificant, while the "raw" materials necessary are so multifarious as to constitute a problem wholly different from that of a works requiring few "raw" materials only, but in enormous quantities. Moreover, the "raw" materials in the fine chemical industry are not "raw" in the same sense, but are the finished manufactured products of other industries.

A classification of fine chemicals is difficult to make, inasmuch as the same substances, and of almost the same degree of purity, may be used for medicinal, analytical, and technical purposes, but for convenience sake we divide fine chemicals into three groups :—(1) Reagents. (2) Pharmaceutical. (3) Technical.

The 1st group includes chemicals for analytical, research, and teaching purposes; the 2nd comprises all chemical substances used for medicinal purposes—(A) the well-known inorganic salts and substances; (B) the lesser-known but considerable and growing group of metallo-organic compounds, *e.g.*, bismuth tribromphenol and metallic salts of organic acids; and (C) the organic synthetic bodies, and substances extracted from plants and animals, of which the vegetable alkaloids and glucosides are important groups; while the 3rd group embraces all other pure chemicals used in the arts and industries, including such widely different products as flavouring essences, perfumes, and photographic chemicals. In considering the 3rd group it frequently happens, owing to the growth of an industry, *e.g.*, kinematography, that a demand for a particular chemical attains a scale so large as to be beyond that usually associated with fine chemical manufacture; and thus this industry passes imperceptibly into the larger or heavy chemical trade.

1st Group. Reagents for analytical or research work are made, perhaps more than any other class of chemicals, rigidly to specification. A very slight alteration in the specification, being only a slight raising of the standard of purity, may involve a complete change in the process of manufacture from that which suffices for a product sufficiently pure for nearly all purposes, and may double or treble the cost of production. In the manufacture of chemicals of extreme purity the choice of utensils for the manufacturing plant forms one of the greatest difficulties.

2nd Group. In discussing the 2nd group in the foregoing classification, it is to be borne in mind that the manufacture of many pharmaceutical chemicals is upon a large scale, so that here as with many technical chemicals, the manufacturer has problems presented to him similar to those obtaining in the larger or heavy chemical industries. In these cases, questions of the design of plant, including the materials used in the construction of it, present difficulties which are all their own and peculiar to each individual case.

It is indisputable that the manufacture of fine chemicals must be undertaken in a systematic and thorough manner and upon a large scale to have any hope of success, the immense number of products and the dove-tailing of processes rendering this a *sine qua non*. Especially is this true of the synthetic organic substances used in medicine, for it is here that the dove-tailing of processes most closely applies. One product hangs upon another; the raw materials for one synthetic substance are a by-product in the manufacture of another; this dove-tailing of processes, and also of materials, being in fact a dominating factor. The business must be on a large scale to enable

it to be carried on profitably, and except in certain favourable instances, which are to be regarded as exceptional, the manufacture of synthetic chemicals cannot profitably be attacked piecemeal.

Utilisation of by-products incidental (we had almost said accidental) to the manufacturing process, has been brought to a fine art in Germany. Many products thus occurring, as it were by chance, have been put upon the market and have come into, or been forced into, use. As has been said by one of us on another occasion :—" If a German factory is producing on the large scale a certain chemical compound, and in the manufacture of that compound a by-product is obtained for which there is no obvious outlet, the research staff ancillary to that factory sets to work to find an outlet for that by-product; it may itself be put on the market and boomed as such, or it may serve as the raw material for the preparation of some other substance. One cannot resist a lurking suspicion that British physicians and British patients have been prescribing and consuming synthetic remedies, merely because by chance something occurred as a by-product in a German factory and an outlet had to be found for it." The demand for many of these German synthetic products during the war has led to unprofitable attempts to synthesise them *de novo*. " Lysidine," a synthetic remedy which has been in some demand since the beginning of the war, will serve as one out of a host of possible examples. The synthesis of this substance depends upon ethylene chloride and ethylidene chloride, which occur as by-products in the manufacture of chloral. Sporadic efforts, though useful and profitable as an emergency or temporary make-shift in war time, are useless for the permanent establishment of the fine chemical industry.

When we speak of the " establishment " in this country of the fine chemical industry we intend no disparagement of those British firms who in the past have been manufacturers of fine chemicals. It is surely not in dispute that the German fine chemical industry has been more systematic, more thorough, more developed, and more successful than the British. The industry in analytical reagents has been mainly in German hands. It is the fine chemical industry in this sense which we have in mind when we speak of establishing the industry in this country.

3rd Group. For the purpose of illustrating the important relation between the Fine Chemical and Allied Industries, certain well-known examples may be taken.

The photographic industry is a considerable consumer of fine chemicals for technical purposes. The manufacture of such salts as the iodides, bromides, silver nitrate, gold and platinum chlorides has been established in this country for many years. When one turns, however, to the manufacture of organic chemicals employed mainly as developers, one is faced with the fact that these have been entirely manufactured abroad. It is unnecessary to discuss here the reason for this condition of affairs, but it is sufficient to indicate that the manufacture of photographic organic developers is peculiarly, though not altogether, dependent upon a ready supply of intermediate products of the coal tar colour works. The aminophenols form the starting point in the manufacture of many of the most successful developers, while a reference to catechol, hydroquinone, and pyrogallol will serve to illustrate our point of the close connection in this respect between the dye and photographic chemical industry. As a laboratory operation the preparation of any of these is not particularly difficult; as an economic proposition, however, the manufacture of this class of photographic chemical is largely dependent on the extent to which the necessary raw materials are themselves manufactured in this country.

The enormous development of the kinematograph film manufacture has still further increased the technical demand for fine chemicals. For this branch of the photographic industry, in addition to the chemicals already referred to, there is an enormous demand for collodions of various kinds, for amyl acetate, for urea and for succinic and sebacic acids and their esters. Another branch of the photographic industry is photo process paper manufacture, which has its special requirements of fine chemicals, gallic acid being of importance. This substance is required to some extent in medicine, but its use in the dye industry, ink manufacture, and the textile and photographic trades is far greater. Ample supplies of photo process paper are needed in shipbuilding, engineering, aeroplane-building, and munition work, but the manufacturers have been handicapped by the shortage of gallic acid and potassium ferricyanide, neither of which substances was being made in this country on a commercial scale at the outbreak of war.

The incandescent gas mantle industry provides us with another example of the technical demand for fine chemicals. The process of impregnating the mantle requires certain kinds of collodion as well as salts of thorium, cerium, and zirconium. Here, as also in the manufacture of metal filament lamps, the manufacturer of pure inorganic salts plays his part. Tantalum, osmium, tungsten, and molybdenum, once the treasures of the chemical curio collector, have become the servants of our daily existence. To take another example, the ceramic industry makes its own particular demands upon the fine chemical manufacturer. While certain pigments, such as the ultra-marines, Paris green, and chrome yellows—largely used in the ceramic and similar industries—have attained an importance which enables them to be manufactured on a very large scale, there are others whose preparation may still be classified under the heading of fine chemical manufacture, and of these cobalt blues, cadmium yellows, and vermilion reds may be taken as types. Another group of fine chemicals in this class is that of the artists' colours, the manufacture of which is a highly specialised branch of this industry. The employment of ionone in perfumery, of vanillin in confectionery and perfumery, and of terpineol in soap manufacture, gives some idea of the wide field covered by this section of the industry.

This very brief survey of some of the uses of fine chemicals in the allied industries will serve to call to mind others to which we have not space to refer. If it suffices to prove that the manufacture of fine chemicals in this country must be encouraged because of its importance to allied chemical industries, then our purpose is achieved.

Interdependence. While the selling side of the fine chemical industry, from consideration of the multifarious purposes to which fine chemicals are put, demonstrates how important it is to other industries, the production side exhibits the reverse view of the relation. The difficulty in obtaining raw materials, especially organic reagents, necessary in the manufacture of fine chemicals, brings home the fact that this industry cannot develop as a separate and self-contained branch—but is indeed directly dependent upon the steady progress of the coal-tar colour industry. Thus we have a fair illustration of the interdependence of the various branches of chemical industry upon one another.

We have stated that the manufacture of synthetic medicinal chemicals is dependent upon the intermediate products of the coal-tar colour industry; without it not only medicines, but artificial perfumes and photographic chemicals,

cannot economically be manufactured. If the manufacture of fine chemicals is to be established in this country upon an economical basis, it is essential that the manufacturers should have readily available sufficient quantities of such reagents as liquid chlorine, sulphur dioxide, sulphur trioxide, phosphoric anhydride, the chlorides and oxychloride of phosphorus, acetic anhydride, acetyl chloride, carbonyl chloride, the chloracetic acids, monochlorotoluene (benzyl chloride), acetoacetic ester, phenylhydrazine, and a host of other organic reagents which are essential in the manufacture of synthetic remedies.

No doubt a fine chemical works should manufacture many of its own reagents, but to carry this beyond a point is uneconomical. The manufacturer of acetylsalicylic acid is hardly to be expected to make his own acetic anhydride or acetyl chloride. These and many other organic reagents and solvents are most economically made on a very large scale, and are outside the province of the fine chemical industry. The newly formed Association of British Chemical Manufacturers should prove most useful here in avoidance of wasteful duplication. Allocation of manufactures up to a point makes for efficiency without, of course, eliminating competition. We may depend upon getting all the competition needful for the good of our souls from abroad without manufacturing it in this country.

The Past. In considering the reason why the fine chemical industry has in the past been peculiarly German in contradistinction of the heavy chemical industry where Great Britain has held her own, there occurs to one's mind the marked reluctance in the past on the part of British chemical manufacturers to take up the manufacture of any product unless there were already to hand or likely to occur a large outlet for it. Among fine chemicals we find this illustrated by the alkaloids, quinine, morphine, strychnine, and caffeine having been continuously and successfully manufactured in this country, whereas the alkaloids of less importance, considered from the point of view of total monetary value involved, such as atropine, eserine, aconitine, hydrastine, and hyoscine, have been largely in German hands.

Business enterprise has been a factor no less important than technical knowledge, as is shown by the fact that supplies of drugs grown all over the world, including even our own Colonies, have been "cornered" by German syndicates, the drugs being sent to Germany to be worked. It is only necessary to mention Egyptian henbane, and also Russian wormseed, the manufacture of santonin during recent years having been under the exclusive control of a German syndicate.

The Present. When we consider the present position we should not lose sight of the fact that a war of such magnitude as this one would have brought about a scarcity of chemicals, even if Germany had been a neutral nation. Further than this, the time, though favourable from the point of view of the cutting off of German supplies is, from considerations of scarcity of labour and materials, as unfavourable as possible to the establishment of any new industry.

It has taken nearly two years for the manufacture of British salicylates to attain a scale and degree of perfection that entitle it to be regarded as "established." Now that this country is self-supporting in regard to its salicylates and acetylsalicylates, it may be hoped that this industry will never again be a German monopoly.

The special difficulties which obtrude themselves so fiercely under war time conditions serve one useful purpose, in so far as they accentuate difficulties which are really inherent to the trade under all conditions, and thus show them up so that they cannot escape discovery and cannot fail to be comprehended. Moreover, the abnormally high prices obtaining temporarily for many products enable manufacturers to acquire their experience in new processes without the financial loss usually to be associated with such ventures. Many difficulties are merely incidental to the war, such as raw materials of quite an "every-day" nature being unobtainable or obtainable only with great difficulty and in limited quantity, or in a less pure condition than under normal conditions, not to speak of the labour difficulty and the slowness of building operations.

The Future. What we are really called upon to consider most seriously is the position of the fine chemical industry in this country after the war; for while much can be done now by way of making a start, the real establishment of a British fine chemical industry upon an adequate scale cannot take place until the national resources in materials, plant, labour, and chemical knowledge are freely available. A supply of technical chemists—true technologists—and of skilled technical labour, will have to be furnished by our Universities, Colleges, and Technical Schools, and no doubt as the industry grows the demand for such technical men will be met by an adequate supply. It must not be complained by the manufacturers, on the one hand, that the supply is not forthcoming, nor pleaded by the teaching institutions on the other hand, that the industry must first provide a field, *i.e.*, that the demand must precede the supply. The two processes must go hand in hand, and since it may take a generation to put the thing upon a proper basis, both manufacturers and teachers should begin at once.

Key Industries. A healthy expansion of chemical industry generally in this country will tend to counteract the effects of over production of certain chemicals when there is a return to normal conditions. The large plants which have been set up in various parts of the country during the present war for the production of explosives as well as other chemicals especially for war purposes, including all the preliminary and intermediate products in the manufacture of these, may be rendered permanently useful if all branches of chemical industry, including that of fine chemicals, are elaborated, and thus provide further outlets for the output of these large plants. For example, sulphuric acid and nitric acid are now produced in quantities far in excess of the country's pre-war requirements; while liquid chlorine is also being produced in quantities far in excess of the pre-war period. The manufacture of synthetic phenol should be perpetuated. When the price of coal tar phenol rises beyond a certain figure, the synthetic product comes into use, and manufacturers of salicylates are thus always assured of a supply of their parent substance at a reasonable price.

Many of these are "key" industries and should be placed upon a permanent basis. It has been stated that no value should attach to the idea of a key industry. Practical experience, however, proves otherwise. We cannot do better than quote the words of M. Henri Hauser, Professeur à l'Université de Dijon:—"We have seen during this war that the absence of certain industries of a fundamental order has prevented the pursuit in the same country of other industries which utilise the products of the first class. How is it possible to make dyes or explosives when phenol cannot be made and when no more of it reaches you from abroad? There are key industries, and the nation which allows such industries to die out from its midst loses the key which opens the door to others. Every industry is in relation to the industry immediately above it in the scale of production. To lose one such key means losing at once the means of opening the doors of the floor above; eventually it means losing the keys of all

the floors." Thus phenol and benzol are the key to the coal tar dye industry, which in turn is the key to the manufacture of many organic fine chemicals.

The importance of chemical industry generally to all industries, and therefore to the national welfare, may be obvious enough to any chemist, but it is not yet understood by the official mind. On the whole, it must be said that the several Government Departments charged with the control of various materials have secured for the chemical industries supplies which have proved fairly adequate, at all events in most cases. Especially useful to the medicine industry has been the N.H.I. Commission—a department which is characterised by business management and absence of red-tape—in avoiding an actual famine in such medicinal necessities as alcohol, glycerin, and sugar. But it is remarkable that manufacturers of important chemicals for contracts direct with the War Office have often had to beg and scrape for their materials. *e.g.*, sulphuric and nitric acids, instead of these being readily forthcoming or even actually reserved. It has to be stated that the importance to the community of the fine chemical industry—especially a supply of reagents—has not been borne in upon the Priority Branch of the Ministry of Munitions. Whether one sees the situation as Gilbertian or merely as sad, it is certainly incongruous that a manufacturer should be bombarded by the War Office, Government experimental laboratories, and munitions works with clamorous demands for reagents and other fine chemicals, while the Priority Branch of the Ministry of Munitions denies the licences necessary in order that these demands may be met.

It is an interesting comment on the importance which is attached to Chemical Industry by the public and official mind to reflect that no Board of Trade Committee has yet been appointed to *inquire into the after-war conditions with which the chemical trade of this country will be faced.* Committees for the Textile, Iron and Steel, Electrical, Shipping and Ship-building Industries have already been appointed, and have made recommendations as to the steps which should be taken to meet the new conditions arising out of the war. We have endeavoured to indicate that to these industries, as well as to many others, it is vitally important that a flourishing chemical industry should exist in this country. Certainly as regards fine chemical industry it seems highly desirable that a Board of Trade inquiry should be instituted to inquire into the problems with which the whole industry is faced, and to receive the views of representatives of the trade as to the steps which should be taken to meet the new conditions.

The committees referred to have realised that there are "key" industries in respect of their particular groups of industry, and they have indicated some of those "key" industries. Is it not of importance that a similar decision should be arrived at in respect of Chemical Industry?

No organisation has existed hitherto among British fine chemical manufacturers such as to enable them to speak and act as an important branch of chemical industry.

The time has arrived when such a voiceless condition should cease. It is to be hoped that the fine chemical manufacturers will now form an association which can represent this branch of the industry in the councils of the "Association of British Chemical Manufacturers," to which reference has just been made, and become an affiliated section of the parent body. If such an organisation can be evolved, having the whole-hearted support of the large majority of the fine chemical manufacturers in this country, determined to sink their petty jealousies of each other, then a large field of highly useful work lies before it. Our growing chemical industry, which aims to place us in an independent position industrially among the nations of the world, must be given a fair chance. National and Imperial interests demand that the enormous and essential trade in fine chemicals shall never again be allowed to fall into the hands of our foreign competitors. The fight for international trade in the future will have to be waged, not by individuals, but by groups of manufacturers.

Discussion.

The President said that in each of the three papers there was a note of warning with regard to the great importance of this country building up a self-contained chemical industry in the same way as it already had done an engineering industry. The man in the street knew perfectly well the importance of the engineering industry, but he did not realise the equal importance of our business in chemicals—whether heavy or fine chemicals. The papers had presented a very clear expression of the important part that the fine chemical industry played in the matter of economy in the nation. Their development could only be attained by organisation among the manufacturers themselves, by sinking their petty jealousies and working together for the common good.

Mr. Thomas Tyrer said that the papers were full of suggestiveness. The necessity for co-operation could not have been more emphasised. The need for pressure on authorities was great. Officials of Government Departments were very different beings when one met them socially—full of sympathy, full of admiration for one's operations and suggestions, but when approached in an official capacity people more difficult to convince he did not know. His name had been associated with the question of alcohol; it had not been forgotten. An official had told him *recently that manufacturers had got all they wanted, and quoted the Society's Journal, referring* to a notification inserted after careful revision by the authorities themselves and with their knowledge, and, therefore with their permission (see this Journal, Dec. 15, 1914, p. 1119). The methylated spirit approved by the authorities was supposed to be suitable for every purpose, but it was not. The Committee on which he had had the honour of sitting had made a good fight, and Mr. Montagu—now Lord Montagu—had fought very strongly for the fact that this was an industrial question. His influence and that of Lord Rotherham, who was there in the interests of labour, had had its effect. Sir William Crookes had stated that by supplying the product at a reasonable price and under reasonable conditions, the amount of business diverted from Germany would be incalculable. A large number of denaturants, suitable for many purposes, was available. Methyl alcohol had been branded as a poison, but the authorities to-day said it was not a poison. When American "alcohol," as it is called, was introduced, it was described as "wood alcohol." It was said that it had a toxic effect only upon those in the habit of getting drunk every day. That was not so. He had observed its effects, and had become convinced that it was a poison. If so, why make it dutiable? The Committee recommended the word "suitable" to qualify a denaturant, but who has to decide what was suitable? The officials on the whole were sympathetic and prepared to adopt suggestions of manufacturers. Dr. Dobbie, as well as his predecessor, Sir Edward Thorpe, had realised their obligation to protect the revenue, but that did not close their eyes to the possibilities of the needs of the nation. The lay officials wanted the money and did not care about science or manufactures. The matter had

been allowed to remain idle for the moment, because of the want of application of the word "suitable," and also because people had become content to remain under the influence of German cheap chemicals. Those who could have made their own reagents had deliberately bought chemicals from German agents and had labelled them with their own labels. We must insist that not only should chemicals be marked "Made in England," but that the maker's name should be put on the label also and that he takes the responsibility. We must do as we did before, namely, approach the Government in the matter. The present Colonial Secretary had then been Chancellor of the Exchequer, and he was intensely sympathetic. He might be able to convince the present Chancellor that in our colonies a most valuable source of alcohol, in the shape of molasses, was being thrown away. In one particular district they were throwing 250,000 tons of molasses a year into the nearest river, or if not into the river into a specially constructed furnace, and in Mauritius 40,000 tons was being wasted. A very important work had been resumed which was stopped by the proclamation of war. Under the ægis of the International Motor Transport Council the question of alcohol for motor work had come up, and the figures obtained as to the amount of raw material which was at present wasted and which could easily be sent home to some central depot were very large. That work had been interrupted, but Sir Charles Bedford and himself were continuing. The authors deserved hearty thanks for emphasising the fact that fine chemical manufacturers could not succeed unless there was co-operation.

Mr. H. M. Ridge proposed that use should be made of this occasion to crystallise out of the large mass of general discussion some concrete suggestions which could be put by the Council to the appropriate Government departments. He believed that if any of our fine chemical manufacturers had seriously attempted to import fine chemicals on a large scale into Germany before the war, they would have been met with the difficulty of finding a heavy tax on these materials.

Dr. E. F. Armstrong thought that the need for co-operation amongst the manufacturers of fine chemicals was the main point to be insisted upon. Unless they were prepared to work together and pool their interests, the future was very dubious. The opinion of the public of the other big co-operations that had been brought about lately through the war, had been that they were going to strengthen our industries very much. From his own knowledge of Germany before the war, he could find no words to convey an idea of the tremendous competition to be met by English firms in the future. Our makers of fine chemicals must strive honestly to produce their chemicals openly labelled with the name of the manufacturer and of the highest state of purity. A good deal of the English materials had not come up to that standard in the past. The alcohol problem had been brought to the notice of a good many on account of the war; many people were using alcohol in enormous quantities—far more than they had done before the war. All those who had to deal with Government officials during the next few months must tell them frankly the truth, and be very definite in explaining facts to these officials, especially what a very important thing it is for our industry that we should have duty-free alcohol. This country with its Colonies could produce alcohol very cheaply, and then they would have a raw material which would enable them to build up a very wonderful industry. With reference to Mr. Carr's statement about the education of the factory lad, it was worth while for the manufacturer to select two or three out of every dozen lads in the laboratory and send them at the firm's expense to continue their education. His firm had done that for many years and the policy had been highly successful. They insisted on the whole of their employees, both male and female, attending evening classes up to the age of 18.

Mr. J. G. Roberts expressed the opinion that the product of the modern secondary school was far better educated than formerly, but to expect that that boy coming into the works was going to do the work of a man was another question altogether. The importance of training boys had been recognised in some industries, and in some North Staffordshire coal mines they had adopted this policy, with the result that a different type of young men was growing up, men who were far more able to adapt themselves to changing or more complex conditions of working, and who were more amenable to reasonable discipline.

Mr. W. F. Reid suggested that the Society might pass a definite resolution to the effect that British chemical industry can only succeed if the Government secure for it as cheap a supply of raw material as any competing nations have. That would include not only alcohol but other materials, such as a number of drugs from which alkaloids were produced. They must not lay too much stress simply on the alcohol question. Mr. Tyrer had done yeoman service in that direction, but it must not be forgotten that many people in high Government offices were strong temperance advocates, and the word "alcohol" to their minds meant something which people should be prevented from having and the manufacturer should not have unless he were subject first to the most stringent restrictions. Certain substances were used as a means of producing revenue, and the great fear Treasury officials had was that that revenue might be diminished. The officials who knew the importance of the subject had not a free hand, whilst those above them who ought to help did not do so because they did not understand anything about commercial or industrial matters. Methyl alcohol was a substance of very great importance in modern fine chemistry, and could be used on a very much larger scale if it could be obtained. We could make it in this country and perhaps make it cheaper if we had not obstacles imposed by our own Government. We should insist upon the raw materials of production being brought into this country at as cheap a rate as it was possible to get them. Other industries had insisted upon duty being put upon raw materials exported from India to enemy countries, and that duty would prevent our alien enemies competing with us. If the same thing could be done in regard to our raw materials we should not rouse the opposition we might do by the free use of the words "import duty" on a manufactured article. Without that being done, he did not see how we were to prevent our materials being cornered by foreign nations.

Professor H. E. Armstrong said that Mr. Tyrer had raised the question of methyl alcohol: surely this was one the Society was able to deal with. He ventured to assert that there was no evidence that methyl alcohol was a poison in any other sense than that in which ordinary alcohol is a poison. He had carried out a very large amount of experimental work with these alcohols and asserted that there was no real case that could be put forward to justify Mr. Tyrer's statement. What was referred to was probably not methyl alcohol. He was very glad to hear fine chemical manufacturers come forward and say that there must be co-operation. They should at once go to the new Association of Chemical Manufacturers and say that they want to co-operate with those who were their competitors. But would they all agree

o meet as practical men? Only recently at the ;ouncil, when the question of a Bureau of Informa-ion was under consideration, it was said that the reat difficulty would be to get manufacturers ngaged in different branches even to disclose vhat they were making. It had been suspected hat many were not making the products they were elling but were putting their labels on other eople's material. That had been done systematic-lly for years past. It seemed that we had the natter in our own hands. It had been said hat we must educate the public and politicians: n reality the Society required to educate tself. It was useless to go to Government fficials—who did not understand our language—nd put these things before them if we were not repared to carry them out. There had been vast amount of dishonesty with regard to hemicals. What was the meaning of the vord "pure"? For instance, "pure zinc" nerely meant zinc that would not show arsenic n a particular test, and that had been true generally. The only person who for many years vould supply pure chemicals was Kahlbaum. Unfortunately, Kahlbaum had deteriorated most eriously in recent years, so that the name had not tood for purity latterly. Why had no Kahlbaum ome forward in this country? It was not always possible to make things on a big scale or to make hings that were going to pay straight away. Everybody now was rushing to make salicylic acid but we could not live on salicylic acid alone, some arrangement was required. We must alter our nature, think less of ourselves so to speak and take on a more patriotic attitude if we were to levelop industries.

Dr. W. Rintoul said that after the outbreak of war the research laboratories at the Ardeer factory of his company had begun to find great difficulty in securing several chemicals that were required, and they had had either to stop the work or to make them. They had decided on the latter course and had been successful. Realising that possibly others were in the same predicament, and that it was not much more trouble to produce the substances on a double scale, they had carried out their experiments on a larger scale, and were gradually developing that idea. They had found it difficult to rely upon the purity of materials bought, and had decided to print an analytical report of the substance on the label of the bottle containing it. They would welcome any chance of co-operation with other manufacturers to prevent overlapping. Right at the beginning they had come across the alcohol difficulty. To obtain trained assistants in their laboratories they had inaugurated a scheme whereby they took boys from elementary schools as apprentices at a comparatively small wage, they having to sign a contract for three years probation, during which time they had to take certain classes. The earlier classes were taken by the School Board officials, but the later classes were held in their own laboratories and conducted by their own staff. That scheme had been running for some three years, and this year they had made arrangements for the classes to be affiliated with the Royal Technical College, Glasgow, so that they might be recognised by the Board of Education. If at the end of the three years the boys had proved satisfactory in their classes and in their laboratory work, they were promoted to laboratory assistants.

Mr. Rutherford Hill supported what Mr. Tyrer had said as to the toxic qualities of methyl alcohol. Both methyl alcohol and ethyl alcohol were narcotic poisons, but methyl alcohol was something like three times as toxic and the symptoms were quite distinctive (Harnack; Pharmaceutical Journal, Apr. 13, 1912, p. 484). There were two things which prevented a supply of cheap alcohol in this country. The first was that it was made a source of revenue to the State by taxation, and, secondly, it was extensively used as a beverage. In consequence of those conditions there were Government restrictions even on the size and shape of a building to be used as a factory for alcohol and as to the size and capacity of the apparatus. In America there were no such restrictions, with the result that the Americans were able to produce alcohol at a very much lower price than we could. Government Departments should be got to listen a little more ungrudgingly to manufacturers who approached them along the lines of that legislation. If that could be done it would solve a great many difficulties. Mr. Dott had referred to the movement for the growing of medicinal plants in Britain. A great deal of nonsense had been talked in that connection. In Scotland, at any rate, they had not the soil nor the climate for the cultivation of medicinal plants. But in India there was such a variety of soil, elevation, and climate, that many medicinal plants could be grown to great advantage which were indigenous to this country as well as to Germany and Austria. He referred to such plants as belladonna and henbane. In considering co-operation and organisation of British industries they should have regard to securing raw materials from British Imperial sources and not allow them to be absorbed by foreign States. The synthetic drug industry was closely associated with the production of dyes, and there should be collaboration between the two. When German dye manufacturers obtained a by-product which was of no use, they tested its physiological properties and then put it on the market under some fancy name. One result of the shortage of these drugs had been to open the eyes of the medical profession of this country to the fact that many of these drugs could be dispensed with.

Mr. Fryer said that he had been associated with Dr. C. A. Keane in working out a method of obtaining novocaine. One of the first substances required was ethyl bromide, and they were compelled to manufacture this. The yield obtained by the published method was quite small, but a little investigation showed that that yield could be increased from two to two and a half times. That had probably been known in Germany although no information had come to this country; he suggested to the makers of fine chemicals that if that kind of information could be pooled it would be of great advantage.

Mr. H. L. Terry said that recently in Manchester there had been several mysterious cases of poisoning which had been eventually traced to methyl alcohol.

The President said that the discussion might be summed up by saying that through the three papers there had run the words co-operation, co-operation, co-operation. They had found it to be most difficult to interest the British manufacturer in novelties. A German manufacturer who took up a certain class of work did not ask whether one were going to buy by the hundred, thousand, or million. He assumed that one had a very good reason for making inquiry for a certain article and he did his best to make it.

Mr. F. H. Carr quoted an instance where his firm had tried to get pure methyl alcohol to make formaldehyde, and after months of correspondence an official had asked why they could not use ordinary alcohol. With regard to Professor Armstrong's remark that manufacturers must be prepared to make things even in small quantities and not insist on large quantities being made, his point was that we must co-operate so that

each should manufacture on the largest possible scale, so as to make it possible to meet foreign competition.

Mr. C. A. Hill said that the trade in products such as Kahlbaum had made, had been very largely in German hands. No one was more keenly alive than himself to the uses and abuses of the word "Pure." His answer on that point was that chemicals ought to be sold to a definite specification, whether they were for analytical purposes or medicinal purposes.

THE PAPER MILL CHEMIST IN WAR TIME

BY J. F. BRIGGS.

The request for a contribution to the discussion on the progress of British Chemical Industries during the war period opens an enquiry as to the position of paper manufacture as a chemical industry and consequently that of the chemist in the paper mill.

Papermaking is capable of being carried on quite successfully without any serious knowledge of chemical principles, and I have heard it denied in the trade that it is a chemical industry at all in the generally accepted sense. It is, therefore, not surprising to find that the majority of paper mills offer but little attraction to highly qualified men in the profession, and the future prospects of the paper mill chemist are not generally such as would give him access to the higher positions. It is this somewhat pessimistic appraisement that we have to combat. It is true that chemistry in papermaking can show few tangible achievements which strike the imagination, such as are recorded almost daily in many other industries which more definitely maintain the ascendancy of the chemist. Nevertheless, the training of the chemist in habits and outlook is such that, even in the paper industry, those directors who have sufficient insight to select a qualified man and sufficient breadth and energy of mind to use him as an intelligent participator in the working policy of the concern, can handle no more promising raw material, and need never regret a somewhat unusual step. On the other hand, a paper mill chemist, engaged in the competitive labour market and left unsupported to seek his own level in the mill, may find, apart from some necessary but uninspiring routine work, but little scope for his chemical activities.

In the paper mill the chemist may find himself the only representative of any kind of scientific perspective, possibly the sole professional advocate of practical economy, in which case he must not expect to be popular, but sooner or later his time will come. In general terms it may be said that the practical industrialist bases his activities mainly on past experience, the commercial man on expediency, whereas with the chemist these are merely useful accessories; the end—if there ever is an end—is the formulation and co-ordination of first principles. Any theory, even a wrong theory provisionally adopted, is better than no theory at all. The chemist must be prepared to travel a long way outside chemistry in the process of "making good" in a paper mill by the application of his special habits of thought, and on his ability and on the opportunities afforded him in this his future position may depend.

To many the war has brought opportunities in various degrees. Both past experience and expediency in some cases have had to come under drastic re-adjustment, and on these occasions a mind trained to work from first principles may render valuable assistance. Especially must the chemist be prepared to think ahead, to gauge the probable tendencies and ultimate effects of rapidly changing conditions, and to suggest possible lines of action.

When the war broke out, business in the paper trade remained very slack for a considerable time. The intelligence department of the mills had to concern itself with the problem of capturing German trade, chiefly in the form of specialities hitherto exclusively in the hands of enemy countries. As a general rule, this movement, which helped to fill up a slack time, was a failure for various reasons. Some mills lost money in experiments, others in filling their books at unremunerative prices. When the turn came, all thought of German specialities collapsed; the public found it could do very well without them. It then transpired that the real volume of German trade to be captured was just in the ordinary kinds of paper, which had been held abroad simply on the ground of price.

However, as regards the specialities, I must mention one striking exception which interests us all as chemists, namely, the capture by the Kentish hand paper mills of the German trade in laboratory filter papers. Although without inside information of this movement, I know that it represents no mean achievement, and must express appreciation of the vigorous readjustment of the practical mind required to give even approximate satisfaction, at so short a notice, to the rigorous demands as to texture and purity built up in the course of decades by the German monopolists. The hand paper mills of the South of England represent a link with the past not merely sentimental, and it is to be feared that an important portion of their trade will be the first to suffer from any general wave of economy such as must rule for many years after this war. Let us chemists, therefore, resolve to support and encourage this new outlet in every possible way, not to be beguiled in future by the attractive little novelties offered from abroad, but to make our requirements and suggestions known through the apparatus dealers to the home manufacturers so that they may consolidate and extend their enterprise to the production of all those specialities for which there is any serious demand.

As to the British paper trade in general, a record of progress in the sense of new developments is hardly to be expected. With restrictions of all sorts on every hand, the papermaker can only be thankful to find himself alive. In many cases, new trade and opportunities due directly to the withdrawal of German competition have had to be abandoned for lack of materials. The United Kingdom is not, and probably never can be, self-supporting in the matter of raw materials for papermaking, and the best that can be worked for in the future is the concentration of their production within the Empire. Although it cannot be asserted that the existence of such a condition at the present time would materially have eased the situation—the dislocation is too far-reaching—still the paper mill chemist is directly concerned to do what in him lies to promote the use of British Empire pulps. The possibilities are few but large, and the obstacles economic rather than technical. While wood pulps from Canada must obviously take the first place, bamboo pulps from our Eastern possessions come easily second. Already before the war bamboo pulp of excellent quality manufactured in French Indo-China was established in the European market. The development of the bamboo pulp industry in British India, when it comes about, will have owed its technical bases in no small measure to the systematic investigations of Mr. W. Raitt, acting under the Government of India. Raitt's report may be taken by the paper mill chemist as an admirable model of the application of scientific principles to technical problems of this order.

The most obvious concern of the paper mill chemist, not only now, but as far as can be seen

into the future, is economy, and so long as the war lasts, it is not merely relative economy of production costs to output which is required, but actual economy of material resources; paradoxically it may even happen that material economy is only to be obtained at an increased cost. No economy is more difficult to enforce than that which demands a change of ingrained or traditional habits, but there is no more effective means of enforcing it than an actual shortage of materials.

The shortage of bleaching powder brought about by war conditions has affected some mills severely, and it behoves those mills which are still receiving supplies to use them in the most sparing manner. In paper mills working esparto and wood pulps two systems of bleaching are in vogue; the quick warm bleach system and the slow cold bleach system. If the former consumes slightly more bleach than the latter, it saves in time and plant, and, when carefully carried out, with bleaching powder at normal prices, the warm bleach process is quite a defensible proposition. But owing to human frailty an excessive temperature is the rule rather than the exception; the working man reasons that if a little heat is a good thing, more must be better, and it is one of the chemist's most difficult tasks to urge moderation in the use of steam. So difficult is this that in the majority of esparto mills the attempt has been abandoned, and the enlarged plant adapted only for cold bleaching represents the most modern practice. Another occasion for excessive bleach consumption arises when the output of the mill overtakes either temporarily or permanently the capacity of its bleaching plant; the machines must be kept fed with bleached pulp, and the process is hastened at the expense of economy. These are some of the reasons why the expected consumption of bleach determined in the laboratory may be exceeded in the mill.

In these abnormal times it is not possible for a mill working the warm bleach system to make the large additions to its plant necessary for the more economical utilisation of the bleach, yet the paper mill chemist anxious for economy may be able to effect useful savings. A study of the published time-curves representing the rate of exhaustion of bleach liquor shows that the reaction at the early stages is really very rapid, even at ordinary temperatures. It is at this stage probably, when the concentration of chlorine is relatively high, that the stimulus of heat is least necessary and most harmful; the fibre is then capable of exhausting chlorine faster than it can receive it, and hypochlorous acid may be lost in the air or otherwise wastefully expended. The most economical results with the warm bleach system with least disturbance of existing conditions are obtained in the following manner:—Run the mixture of bleach liquor and pulp for an hour and a half at the ordinary temperature, then proceed with the gradual admission of steam through a small perforated pipe extending right across the floor of the engine in front of the roll, of such a size that the maximum temperature of 100° F. (38° C.) is reached only after one hour; shut off the steam and allow the bleach to exhaust itself at that temperature. In this way economical results comparable with those of the cold system can be obtained in 3½ to 4 hours; any more rapid effect than this is likely to be purchased by an undue expenditure of bleaching powder.

Another principal chemical operation in the paper mill is the sizing process. In the economy of resin size such progress has been made in the last ten or fifteen years by the efforts of competitive size vendors that little margin now remains; the number of mills which consume size wastefully is now probably extremely small. In the consumption of sulphate of alumina, however, there is still room for considerable economies. Every paper mill chemist knows perfectly well that the quantity of sulphate of alumina consumed in acidifying a soda-boiled, bleached pulp may be as large as, or larger than, that usefully employed in precipitating the size. This knowledge is utilised in many of the rag paper mills where the stock, after bleaching, is soured by a weak vitriol treatment and the basic calcium compounds deposited therein are cleared out. Yet in most, if not all, esparto mills, where the necessity is still greater, this obvious economy has been neglected until the scarcity and high price of alum cake caused by the war has forced the question to the front.

The souring of the pulp is an operation which must be made as far as possible "fool-proof," because a slight trace of free acid in the finished paper would be disastrous to the sizing, and bring the process into discredit. For the communication of the following simple but effective method of bringing the process under safe control, thanks are due to Messrs. Tullis, Russell and Co., of Markinch, who make it public for what it is worth in the interests of national economy—to themselves its adoption has been worth from £15 to £20 per week. Instead of vitriol, nitre cake is employed in spite of the trouble involved in dissolving it. The nitre cake solution is made up at a density of about 60° Tw., and sufficient is added to the pulp in the beaters, before sizing, to make the whole definitely acid to litmus. The quantity is so regulated that the acidified pulp becomes alkaline again after the size is in, and, provided this condition is fulfilled, no harm can result. The margin allowable for unavoidable variations is fairly large, and although the personal attention of the chemist is required for fixing the amount of acid to be added to each type of pulp, the continuation of the procedure may be entrusted to the ordinary attendants. The predominant alkalinity of the size spreading through the acidified pulp preserves the liberated resin in the state of emulsion, and the danger of clotting which might result if the order of treatment were reversed is avoided. When the size is mixed with the stuff, sufficient of the ordinary sulphate of alumina solution is added to restore the definite acidity to litmus. In the case of bleached esparto and wood pulps, a saving of from one-half to two-thirds of the usual consumption of sulphate of alumina may be effected.

In conclusion, a word may be said on the question of investigations of a non-remunerative order. It is desirable that the mill chemist should formulate mental pictures of the intimate nature and mechanism of all the materials and reactions with which he has to deal. Without the resources of a University laboratory and possibly in an unsympathetic environment, such work, of necessity done at odd times and often spoiled by more urgent calls, is apt to be of the kind described as "scrappy." Granted that the manipulative details are tedious and connected results of serious scientific value not readily obtained, nevertheless let this be no discouragement; the paper mill chemist must resist the temptation to sink into a rut of routine: let him keep his mind young by thinking everything out on theoretical lines and putting his conceptions to the test quite apart from the question of immediate utility. Every wise director will encourage this form of mental exercise, as time and opportunity permit, because by doing so he ministers to the spiritual as well as the material needs of his business. There are still plenty of subjects for pure and semi-pure research work among the every-day objects of the paper mill. The chemical nature of lignocellulose in its various manifestations, the proximate composition of raw esparto, the relationship of esparto and wood

celluloses to the normal cotton cellulose—very little is known about these complex subjects, and much of that is probably quite wrong.

DISCUSSION.

Mr. ALLAN SMITH agreed entirely with most of Mr. Briggs' statements. His own experience had been principally in wood pulp, and the suggestion Mr. Briggs had thrown out that esparto should be dealt with in the same way as wood was a very practicable one. There was probably no one firm now using esparto in sufficient quantities to enable them to have a plant which could be worked in that manner. Those materials must be worked in large quantities. In England the largest digesters he knew of had a capacity of 25 cwt., while on the Continent it was a common practice to have 15-ton digesters. It was just as easy to deal with a big unit as a small one.

Mr. W. F. REID suggested that our paper-makers should produce a pure form of pulp for the manufacture of collodion and explosives. The Germans now made the bulk of their nitrocellulose from wood pulp, and, so far as he was aware, the manufacturers in this country had not devoted themselves to the production of the pure pulp.

Mr. SMITH said that the wood cellulose industry would never become a profitable business in this country. It must be in a locality where timber was abundant and water-power cheap.

Mr. BRIGGS agreed with Mr. Smith as to the wood pulp. The same argument did not apply to esparto, because esparto could not be manufactured into cellulose. The reason that the cellulose made by the paper makers was not pure was that the paper maker was only a cellulose maker in a subsidiary degree. So long as he obtained from his machine a sheet of white paper free from dirt he did not care whether the cellulose was pure or not.

THE ANNUAL DINNER.

The Annual Dinner was served at the Balmoral Hotel, Princes Street, and was attended by a large number of members and guests. The function being of an informal character there were no speeches. Following the loyal toasts, Mr. Tyrer gave the toast of the Edinburgh Section, to which Dr. Longstaff briefly replied, and the toast of the President was proposed by Prof. Irvine.

THIRD DAY.

FRIDAY, JULY 21ST.

THE OVERHAULING OF OUR PATENT LAW.

BY J. W. GORDON, K.C.

In the current number of the Quarterly Review Lord Parker, writing of the industrial problems which will come up for solution after the war, refers among others to the problem of the Patent Law, and says:—

"We should endeavour to encourage new inventions and to secure that new inventions when made shall be brought into use at the earliest possible moment. Our patent laws are justified by the desirability of encouraging new inventions but it is very doubtful whether they have that effect, while they are often used to prevent new inventions being utilised at the earliest possible moment. In this connection we should reconsider and overhaul our patent laws."

Of this text I gladly avail myself to clear the ground to-day of much matter of unprofitable argument. In the course of prolonged discussion of this topic I have learnt that it is exceedingly difficult to make the majority of people believe that our patent law needs to be overhauled at all, and that the difficulty is still greater, with the majority of that minority which accepts this general proposition, to induce them to view the matter from the stand point of the public interest.

Your interested hearer is generally either some inventor with a grievance because his patent turned out to be invalid or an infringer who thinks that no patents ought to be granted at all or an enthusiast with a fad. To have the point of view of the public defined and the need for improvement asserted by a Judge having the professional and personal authority of Lord Parker, is so great an advantage in opening this discussion that I do not propose to go beyond this dictum along that particular line.

It is not possible, however, to leave the point in these quite general terms. For the successful discussion of a remedy it is necessary to have a definite idea of the mischief to be remedied, and therefore, I will venture to add by way of illustration of the point involved, an example of the mischievous operation of our patent law. The palmary example is the case known as the Levinstein Case—the story of which has often been told, but may for the sake of the moral involved be briefly told again.

The Levinstein Case was brought to trial in 1883 —the same year in which Mr. Chamberlain's Patent Act passed the Legislature—and it may be said therefore to belong to an earlier period of patent law administration. That is perfectly true, and in drawing inferences from the facts of that case certain modifying circumstances must therefore be borne in mind. But the modificatons are so small and the main facts so striking that the case remains still the best possible example of the mischief which calls to-day for remedy.

Shortly stated, the facts were these. The Badische Aniline Company had patented a sulphonic acid dyestuff yielding brown and yellow tints. The invention was original and the patent perfectly good. It was not commercially valuable because the colours produced had no vogue and consequently no market. Four years later Levinstein independently invented another dyestuff of similar chemical constitution, which was of a red hue and had a great vogue under the name of Blackley Red. To what extent if at all he had been guided in his experimental work by the Badische specification I do not know. That he had made an original contribution of importance to the whole result is evidenced by the fact that his Blackley Red was made by a secret process the secret of which was unknown to the Badische chemists. Although chemical tests enabled them to discuss the analytical nature of the new substance they were wholly in the dark as to its synthesis. That from the point of view of synthesis it was something quite different from the invention which the Badische people had made was proved by its remarkable hue. But the poverty of language obscured this distinction and enabled the patentees to set up a claim which in terms covered the red dye as well as the brown. This claim was upheld, the patent right enforced, and an injunction granted to restrain Levinstein from manufacturing Blackley Red. No injunction was required to restrain the patentees. They were restrained from manufacturing it by the fact that they did not know and were unable to discover how it could be manufactured. In the whole result therefore the red dyestuff could not be manufactured at all in this country. The only dye maker who was enabled by knowledge to produce it was disabled by law, and this extraordinary situation emerged. A patent which had been granted to secure the establishment within the realm of sulphonic acid dyestuffs was so manipulated as to prevent the establishment of the manufacture or, to be more precise, was used to suppress that manufacture when it had been established here. You may doubt, if you like,

the soundness of the law which brought about that result, but you can hardly, I think, doubt that the Judge who pronounced the judgment expressed a wholesome sentiment when he formed the following sentence in his judgment :—

"I cannot come to this conclusion, I must honestly say, without some regret. I think Mr. Levinstein has employed great knowledge, great skill. and great perseverance in finding out these processes, but I am sorry to say that the law compels me to inform him that these processes cannot be used in the production of this colouring matter, seeing that the production of this colouring matter is protected by a patent."

A word or two must be added as to the sequel of this case. The defendant was a man of resource and did not allow himself to be coerced into submission to his trade rivals. He established the manufacture, which continued to be secret, in Holland, and Manchester manufacturers of cotton goods continued for many years thereafter to send their fabrics to Holland that they might there be dyed with Blackley Red. A large industry, the commercial value of which may, if I have been correctly informed, be estimated in millions of pounds, was then transferred from Lancashire to the Netherlands in order to vindicate the patent rights of a German firm in respect of an invention of which the intrinsic value was less than half-a-crown, was, in fact, a negative quantity. It needs no argument to produce the conviction that such a result is preposterous and the law which brought it about was unsound. This conviction had indeed established itself in the minds of thinkers conversant with the Patent Law before this date. The action was tried, as I have already said, in the same year—1883—in which a Patent Law Amendment Act was passed and one of the Clauses in that Act was designed to eradicate this very mischief. It was thereby provided that in certain cases, of which the Levinstein case was typically one, a patentee might be compelled to grant a license to a person whom. for want of a better word, I may perhaps be allowed to call an intending infringer—thus substituting a license to use the invention for an injunction to prevent its use. It will therefore be understood that inferences drawn from the law and the facts of the Levinstein case must be cited only with due regard to changes which the Act of 1883, and subsequent Acts of Parliament, have introduced into the Statute law. If those changes had produced their intended effects they would very greatly have modified the situation, but in fact they have one and all failed of their purpose and in the result have scarcely modified the situation at all. Injunctions are still granted as freely as in 1883 and with equal disregard of consequences. The whole machinery of compulsory licensing and compulsory working has with something like a maximum of effort produced a minimum of result. To discuss the reason of that fully would expand this paper to an inordinate length, but in order that I may not seem to dogmatise let me indicate in a word what I take to be the vice of all this recent legislation. It is superficiality. The system of compulsory licensing is in theory admirable, but the mode which the Legislature has devised for bringing it into operation is so complicated and circuitous as to be impracticable. The child has been strangled in its own swaddling clothes. So again with compulsory working. Superficially it looks perfectly sound—the logical outcome and necessary corrollary of a system of patent grants. But when you come to work it out in practice you find that, like many other counsels of perfection, it is "far too rare and good for human nature's daily food." You cannot formulate a rule of practice under this head that does not require to be hedged about with exceptions. You cannot formulate your exceptions at all but must always be prepared to add to them at discretion, and so by the time you have elaborated a working scheme you find that you have created a codeless mass of dicta fit to serve no useful purpose but only to be an instrument of oppression. These are mere hints, but I dismiss these topics without more ado because the one topic to which I desire this evening to direct attention seems to me to be immeasurably more important.

The illustrations which have just been submitted of the injury suffered and the remedy proposed both point to the injunction to restrain infringement as being the real source of the mischief. This I believe to be the case, and my contention is that if the jurisdiction to grant injunctions were subjected to proper control we might with advantage repeal all the complicated enactments touching compulsory licenses and compulsory working for those things would automatically settle themselves.

For the discussion of this proposition it is necessary to have a clear notion of what is signified by an injunction. The subject is so highly technical that a word or two of explanation may not be out of place.

It should, then, be premised that the administration of the law proceeds along two main lines—the civil which is concerned with questions of property, and the criminal which is concerned with questions of conduct. The two departments cannot be wholly separated for the possession of property implies duties, and duty and interest are sometimes in conflict. Hence arises a third branch of law, neither purely civil, nor strictly criminal, but in which both interest and duty come into question. This is known among us and in the British Dependencies and America as Equity, and from time immemorial it has, among ourselves, been administered by the Lord Chancellor and by his puisne judges known originally as Vice-Chancellors, and in our own times as judges of the Chancery Courts or Chancery Division of the High Court. A complicated nomenclature has somewhat obscured the distinction between these three jurisdictions. Thus, the criminal and purely civil law has been administered by what are known as Common Law Courts and are ordinarily spoken of collectively as the common law. On the other hand the civil law and equity are administered together so far as possible as one system by the High Court and are commonly spoken of together as civil business of the Court in contradistinction to its criminal business. Finally, the term "civil law," used in a technical sense, is employed by legal writers to describe that body of law, founded upon the ancient law of Rome, which prevails largely on the Continent of Europe. and has deeply coloured our own law of probate, admiralty and marriage. In contradistinction to this term the expression, common law, is used to signify our indigenous law not embodied in statutes. Thus, both the terms common and civil law are ambiguous, until defined, in the language of English lawyers and ideas are apt to be hazy in consequence. But we may speak of criminal law, common law and equity in a perfectly intelligible sense of the words as covering the whole ground of jurisdiction. Roughly, criminal law is concerned with the restraint of bad men, common law with the regulation of the conflicting interests of good men or men not necessarily bad, and equity with the adjustment of those difficulties which arise out of the conflict of interest and duty. Thus, the criminal law is concerned with conduct almost exclusively and very little with property, the common law with property and its rights almost to the exclusion of motives and ulterior consequences. Equity is concerned with both and

comes into play only when both are involved. It takes cognisance of conduct as affecting property and controls the exercise of proprietary rights in the interests of recognised duty. It thus has affinity with both the other systems and it is out of this affinity that the injunction—a characteristic invention of the equity courts—has arisen. A wrong of which the criminal law will take account is a crime and as such punishable by fine or imprisonment or both. A wrong with which the common law is concerned is a tort if no contract is involved—or a breach if it grows out of a contract. In either case it is remediable by damages. A wrong of which Equity will take cognisance is a breach, it may be of trust, it may be of duty, and is remediable either by performance or failing performance by damages. Performance is the characteristic equitable remedy and to secure performance coercion must in most cases be resorted to. The injunction is a contrivance for enabling the court to exercise such coercion by converting a breach into a crime and so investing itself with the coercive powers of the criminal law.

This is, obviously, a very dangerous kind of remedy requiring to be used with studied moderation and careful regard to the public interest; for the indiscriminate use of injunctions would evidently result in an absolutist system of government under which our duties would be settled for us, not by general rules, but by special directions issued by Judges who would enforce obedience to their slightest dictum by the penalty of imprisonment at the discretion of the Court. This arbitrary element in the injunction has always made it unpopular with English lawyers, and at one critical period in our history a Court—the Star Chamber—which founded its procedure on injunctions was swept away by a torrent of popular indignation. For something like three hundred years after that event the injunction remained an exceptional remedy reserved for exceptional occasions, and to my thinking it is a mark of decadence in English law that in our own times this powerful instrument of oppression should have been introduced once more into common use. That, however, opens up a much larger question than the one which we are considering to-day, and it is more to the present purpose to point out that in certain branches of the law resistance against this innovation has been successfully maintained down to the present time. Thus, for instance, the injunction is practically unknown in the Commercial Court, and at Common Law the employment of injunctions to enforce the recovery of money due under a contract has been placed under strict regulation by the statutes abolishing imprisonment for debt. In all questions touching commercial contracts the courts exercise arbitral, not arbitrary, power and the restriction has been found to be essentially important for the public well-being.

Building upon the lessons of experience thus enforced one may point to the sound rule touching the maintenance of patent rights. For there can be no conceivable reason for adopting a sharper rule of law for the enforcement of patent than for the enforcement of contractual rights. So long as a patent gave to the patentee an unqualified right to prohibit the use of his invention by anybody whom he did not choose to license, there was much to be said for the injunction seeing that only by an injunction could that right be enforced. But no such unqualified right is given by any existing patent. All patents now are subject to the subsisting, although ineffective, rights conferred upon the public by the compulsory licensing and defeasance clauses of the Patent Acts. Thus, the theory of patent law has been reformed, but an unreformed system of administering the law has reduced the theoretical reform to something very like a nullity. A demand for further reform has arisen. The Paris Conference has recognised it and has included in its resolutions one to the following effect:—

"The Allies undertake to convene a meeting of technical delegates to draw up measures for the assimilation, so far as may be possible, of their laws governing patents, indications of origin and trade marks."

The demand, as you have seen, has been formulated in this country by no less an authority than Lord Parker, and it may reasonably be supposed that at no very distant date the matter will engage the attention of the Government and of the Legislature.

It thus becomes a matter not only of interest but of urgency to consider the question of patent law reform and to take stock of the proposals which will be pressed upon the attention of Parliament. In arguing for the consideration in this connexion of an improved rule concerning the granting of injunctions, I hope to engage the interest of the Society in this reform and perhaps its support of a definite proposal on the subject.

In framing the terms of any such proposal two considerations should be borne in mind. There is, first, the mischief, already illustrated by the Levinstein case, due to the indiscriminate issue of injunctions in support of patent right and, in the second place, there is the consideration—not less important—of the case in which a patent right cannot be exploited to the best advantage of the public save as a strict monopoly of the patentee. This latter case may be illustrated by the telephone monopoly. To render efficient public service the telephone system—like the inland telegraphs—must be a monopoly. Even if no question of patent right were involved the telephone monopoly would be justified on the same principles upon which gas and water works are made monopolised industries. The original telephone system was in this country built upon patents, and there seems to be no reason why it should not during its experimental stages have been protected by injunctions based upon patent rights. Sooner or later, if the system succeeded, it was sure to become a monopoly. The original patentees, if able to carry the undertaking to a successful issue, would naturally, and very properly, become the undertakers of the business. If they proved unequal to the task and a new telephone authority had to be set up it would be easier to expropiate one than a dozen different undertakers. It may well be that in a case such as that good cause could be shewn for the protection of the patentee by an injunction. But that is a widely different thing from the indiscriminate granting of injunctions without any regard to the public interests involved, and it is this indiscriminate use of a very dangerous weapon which constitutes the mischief now under discussion.

Assuming that point to be sufficiently clear, I pass now to consider briefly what is the remedy. Many remedies have been proposed. These are:

1. The compulsory license introduced into our law by the Act of 1883 and re-enacted with modifications by the subsequent statutes of 1902 and 1907.

2. The compulsory working obligation copied from the Continental code and incorporated in the Act of 1907.

3. The penal clauses of the 1907 Act which deprive a patentee who makes an improper use, in certain specified ways, of his monopoly of his right under the patent to an injunction and award of damages against an infringer.

This is a sufficiently formidable array of remedies but they have proved to be almost wholly ineffective. Various reasons must be assigned for this result.

To take them in their order:

1. The compulsory license remedy would probably have met the whole difficulty, and is certainly, if I may offer the opinion, the most promising remedy that has ever been proposed. But the sound rule against circuity of procedure was set at naught when the scheme was originally embodied in legislation; and Parliament, instead of investing the Court, when trying a patent action, with the power to give a remedy in the form of a compulsory license, devised a circuitous procedure of sending the Defendant to the Board of Trade, thus establishing a conflict of jurisdiction and aggravating the cost of litigation. To carry on the two causes at one and the same time would be embarrassing to both parties to the litigation, and it is not surprising that under these conditions the plan, notwithstanding its excellence, has failed of good effect. Half-hearted attempts were made by the Patents Acts of 1902 and 1907 to remove the clog. The first mentioned made matters definitely worse by sending the petition for a compulsory license to the Judicial Committee of the Privy Council—a most respectable but withal a most impracticable tribunal for that purpose. By the Act of 1907 the Supreme Court was at last made the tribunal for deciding a question of compulsory license, but by a positively whimsical incongruity the jurisdiction of the Supreme Court was limited to the hearing of petitions presented to the Board of Trade and referred by the Board to the Court. Thus the fatal clog of the circuitous procedure has been assiduously preserved through all changes of the law, and the draughtsman has been allowed to nullify the measures which Parliament has approved for the remedy of this mischief.

2. The compulsory working obligation. This is a remedy borrowed from the Continental systems of Patent Law, which appears, on superficial consideration, to be the obvious thing. If a patent is granted in order that the patentee may introduce an invention into use, what simpler and more logical than to make the bringing of the invention into use a condition of the continuance of the grant. But, tried by the criterion of experience, this remedy is found to be logical indeed—but not remedial. To begin with, merely repealing the patent does not set the manufacture going. If it did a better remedy still would be to grant no patents at all. Then the condition of compulsory working is always and necessarily qualified by a limit of time within which the patentee is not to be harried by the compulsory working condition. But no fixed and invariable time limit will meet the case. How far it is from meeting the case may be illustrated very strikingly from another provision of our patent law. No British patent right can run for more than fourteen years. But in certain cases a renewal may be obtained at the expiry of the fourteen year period. That is only when the patentee has been quite inadequately remunerated because he has failed to bring his invention into sufficient use. Of course the failure must be through no fault of his own. But the failure which constitutes a ground of forfeiture need not be through any fault of his own. The same failure to exploit the invention may at one stage be a ground of forfeiture and at another stage a ground of renewal of the patent right. In truth the verbal logic is misleading. When you look behind mere texts and consider the essence of a patent grant, it is a contrivance for producing the effect of which Lord Parker speaks, *i.e.*, for securing the bringing into use of new inventions at the earliest possible moment. If then a particular grant fails to accomplish this end the reason is that it has been granted to the wrong patentee and the congruous remedy would be, not to repeal the grant, but to expropriate the grantee and put some better patentee in his place. This is substantially what the compulsory license does. The repeal of the patent only destroys the proprietary interest which was created to promote the use of the invention. It is a doctrinaire measure devised to deal with one particular kind of obstruction, and adapted to that end. But as that particular form of obstruction is by no means the most serious difficulty by which the introduction of new inventions is beset, the remedy has not unnaturally proved to be worse than the disease. If the power to veto the use of an invention were taken away from patentees the mere existence of dormant patents would be no mischief at all.

3. The penal clauses of the Act of 1907 do not call for any special notice here. They are very special matters intended to repress particular abuses of patent right and except in so far as they are covered by what has just been said under the last head, they do not substantially affect the present discussion.

The conclusion of the whole matter appears to me to be this. Our patent law could be easily reduced to an extremely simple form, in which the patent grant might be expected to produce a maximum of public advantage, by reducing the grant to a qualified monopoly which would in all cases confer upon the patentee the right to grant licenses but only in exceptional cases the right to restrain by an injunction the use of the invention. This reform is urgent, and if carried out it might be accompanied by a repeal of the intricate legislation and vexatious penalties of the last Patent Act. The patentee would then be in this position, that by promoting the use of his invention he would be turning his patent right to value whereas he could derive no profit from it by suppressing the use of the invention within the Realm. When that is his position the patentee will no longer be able to do any mischief, while the power for good will remain intact. When once that position is reached we need not trouble any more about penalising patentees. They will be the servants and not the masters of the public.

In conclusion I should like to submit the suggestion that here is a subject which a special Committee of the Society of Chemical Industry might be most advantageously appointed to consider. It closely concerns the industries in which you have a special interest: it is a live question upon which legislation will almost certainly arise in the not distant future: first, to form, then of formulate, and, finally, to enforce your views on this important subject would be the fitting task of as strong a Committee as you could appoint. May I beg forgiveness for venturing to suggest the scheme and to commend it to your favourable consideration.

THE INFLUENCE OF PATENT LAWS UPON INDUSTRY.

BY WALTER F. REID, F.I.C.

(Chairman of the Institute of Inventors.)

At this critical moment in our history it is well to consider whether and how we are handicapped in our competition with other countries by the laws which control our actions and our industries. All civilised communities have found it necessary to regulate the conduct of individuals by a more or less complicated system of regulations, the main point of which should be that isolated units of our social system may not injure the community as a whole. Until recently we prided ourselves on giving more freedom to the individual than other nations, many activities carried out in other countries by the State being here left to individual effort. In the past, individualism had its advantages; but speed of communication and rapidity of transport have so altered the conditions of

intercourse between nations that collective action must be substituted for individual effort, if we are to maintain the position to which we deem ourselves entitled. In an ideal community it might be possible to arrange the division of labour so that each would perform the task for which he was fitted. By "labour" I do not, of course, refer to the narrow-minded, horny-handed variety; but to every activity necessary for the good of all. Failing such utopian conditions the best alternative seems to be for the community, as represented by the State, to hold the balance fairly between the various classes of workers so that none of them may be handicapped in their efforts for the common weal. If there is one class of workers to whom humanity in general is most indebted, it is the inventor. All our comforts, our means of subsistence, our industrial appliances, our weapons of defence have been at one time new inventions. Technical education really consists in transmitting to the possible inventors of the future the inventions of the past and present. Those who have been and are teaching research work are beginning to find out that work is none the less scientific when it has a definite object in view that may benefit mankind.

But research, although an important step in advance, is not the final one. Before research can be of use the inventor must intervene and apply the results to some existing or new industry. The researcher may himself be an inventor; but this is by no means always the case. Perhaps the majority of modern inventions are more or less based on work done by others than the inventor whose name becomes known in connection with the subject. It has been truly said that the inventor is born and cannot be evolved by any process of education any more than a good painter, musician, or author can be produced by such means. What can be done, however, and this is where technical education and practical experience are so important, is to teach those who have the inventive faculty what others have previously done or are doing, so that a valuable gift may not be wasted in the duplication of work already done. In patent specifications and recently in the records of the Institute of Inventors there are numerous cases where different people have evolved the same idea, and such repetitions will no doubt continue; but they may be diminished by technical training. Again, an invention may be apparently perfect and yet, when put to the test of experience, it may not effect the purpose in view. Ericsson, the celebrated inventor, took a house infested by rats and evolved a rat-trap that was described as a marvel of ingenuity, but the rats would not go near it and the inventor remarked: "These little beasts have brains altogether too big for their heads." Very few inventors are endowed with the business faculty and, from the natural point of view, this is an advantage. Business men are very numerous, good inventors very scarce, and, if it could be done, it would be better for inventors to allow others to apply their inventions and themselves to continue the use of the faculty with which they are endowed. The "instinct of contrivance," as it has been called, is irrepressible, and very few inventors indeed can resist spending the money gained by one invention on some new one. Edison spent most of the money gained in electrical work on a gigantic scheme for the utilisation of the magnetic iron ore of New Jersey. When it failed, a financial friend told him that the amount spent was £800,000; and Edison replied: "Well, it's all gone, but we had a hell of a good time spending it."

As a rule the inventor receives but a very small fraction of the wealth which he is instrumental in creating. The popular notion that inventors become wealthy monopolists is erroneous. Only 4% of the patents taken out are continued to the 14th year and only 52% remain in force even at the end of the 4th year. The great undertakings connected with such names as Dunlop, Welsbach, Marconi, Nobel, and many others are combinations of shareholders, some of whom have very small holdings, and their success depends, not on patents which may have long since lapsed, but on sound commercial management. Inventors have undoubtedly created great industries, found employment for many millions of workers, and added to the comfort and working capacity of their country. But what does that State do for them? In return for an exorbitant fee they are granted a patent which, contrary to a popular belief, is not a monopoly at all, but merely a license for litigation. The Government having secured his money, renders the inventor no help should his rights be assailed and leaves him to fight his own battle should anyone attempt to rob him of the fruits of his labour. In view of the enormous advantages accruing to that country in which new industries are originated and developed, it would be an excellent investment of public money to pay all a patentee's fees and expenses; but what do we find a short-sighted Government department doing? A tax yielding a net profit of about £100,000 per annum is levied on inventors, and, to do this, a staff costing last year £145,613 is maintained. The total amount paid to the Patent Office last year in fees was £275,000. A large portion of the expenditure is incurred in making useless searches through the patent specifications of the last 50 years, a search which is of little use to the patentee and is looked upon with ridicule by capitalists of any experience in patents. When we consider that an inventor can derive no profit from a patent until it has been at work for some time the folly and hardship of adding to his difficulties at the beginning by heavy taxation become evident. Patents were formerly issued by needy sovereigns in want of money; are we now much better off than in the days of the Star Chamber?

Truly the Patent Office is one of the greatest of the many failures of the Board of Trade and British inventors can have no chance in competition with their foreign rivals until it is completely re-organised. Commercial men are crying out for a Ministry of Commerce; but industrial and technical interests are even more concerned in having a government department to deal with in which the officials are not incapacitated by the defects of their education and by hidebound official habits from dealing intelligently with the pressing needs of the day.

Some of the most useful inventors are working men whose daily occupation makes them familiar with processes and machinery. From the experience of the Institute of Inventors I have no hesitation in saying that many valuable inventions are lost owing to the lack of means of men who are thoroughly familiar with their subjects, but wish to protect their ideas before disclosing them. Some short-sighted employers object to their workmen developing new ideas; such firms soon lose ground and ultimately succumb to the rivalry of others who keep more up to date. Their workmen, seeing no scope for their inventive ability, leave and take their experience and ability with them.

The present war has shown how dependent we are upon the inventor, even for our national existence. It is a war of wits as much as of men and money, and without the hearty co-operation of chemical experts and especially of the members of our Society, Great Britain might have been in a very serious position. Our officials had been thoroughly warned, but the majority of them are

so lacking in scientific and technical education, that they could not fully realise the importance of the warnings given. We have suffered heavily in consequence and have not yet fought our way out of the inferior position in which we found ourselves at the outbreak of war. As one of your Representatives, I called the attention of the President of the Board of Trade to the serious position we were in, in 1906, as regards explosives, and some action was taken in connection with the Patent Law.

When the war is over an industrial contest will begin for which we are ill prepared. Our present enemies and future trade rivals found a most efficient weapon against us in our own patent law. Their patents are now being carefully nursed and profits collected for them, and when peace is declared the old state of affairs will continue, if we do not stop it. In my opinion the whole management of the Patent Law Office should be re-organised. It should have as its head a man of the highest scientific and technical training, preferably one with some knowledge of English words and their meanings. If he has some experience of British industry so much the better. A mere university training is quite insufficient for the head of an establishment dealing with complicated technical and industrial matters. The inventor should be treated sympathetically and not merely as an individual from whom excessive fees are to be extracted. Practically the only advantage which the patentee derives from the Patent Office is the excellent and well-managed reference Library, the best of its kind with which I am acquainted. Our Society is endeavouring to get similar libraries established throughout Great Britain; they would be extremely useful to inventors and technical men generally. There are many free libraries throughout Great Britain, but most of them seem to have become purveyors of cheap and not altogether healthy-minded novels.

If we assume that the inventor is entitled to have his ideas protected, the question next arises, how is this to be done? In the first instance, he should be consulted when alterations in the Patent Law are being made, which has not hitherto been done. Every other interest has been fully represented on such occasions, but not the inventor himself, the chief party concerned and the one who supplies the funds. One injustice of the present system is that if a patentee does not pay a fee on a given date, his patent lapses. An inventor may be deprived of the fruits of years of labour, perhaps through the carelessness of an agent. Soon after the outbreak of war, the Institute of Inventors approached the Board of Trade asking that patentees who, on account of the interruption of business caused by the outbreak of hostilities and the consequent action of the Government, should be unable to pay their renewal fees, might have the payment suspended until the conclusion of war. Nothing was done by the Board of Trade; but several technical societies have since taken action in the same direction, notably the Institution of Automobile Engineers, which passed the following resolution:—"That in view of the conditions arising from the war, precluding very many Patentees from deriving any benefit from the monopolies granted to them, the Government be respectfully but very strongly urged to grant Patentees the option to suspend their Letters Patent until peace is declared."

In view of the members of the Society of Chemical Industry being seriously affected by the present state of affairs, our Council might well associate itself with the action taken by similar bodies. The Board of Trade have power under the Act to prolong a patent; but what is wanted is a declaration that a patent may be suspended during the war.

There are many other points in which chemical industry is handicapped by the existing Patent Laws; but time will not now permit of reference to them all.

THE DISADVANTAGES OF THE PRESENT PATENT LAW.

BY W. P. THOMPSON.

The main disadvantages of the present law are first, that a vast number of patents suffer an untimely death through the heavy annual taxes which the inventors often find it difficult to pay; secondly, the tremendous law costs at present necessary in fighting patent actions; third, the unsatisfactory way of assessing costs and damages in these actions; fourth, the opening left to fraud, and useless expense, caused by our system of provisional protection; fifth, the uselessness and, indeed, pernicious nature of the compulsory working laws as at present existing; sixth, the shortness of the duration of patents; and seventh, a patent, other than a convention patent, cannot be taken out by the assignee.

First.—The Annual Taxes.

This, of course, is only a very small thing to wealthy chemical manufacturers, but to poor inventors it is a very serious matter. In 1883 when the taxes on applications were lowered to about one-fifth of their previous amount, leaving the annual taxes the same, the net income of the Patent Office was only very slightly reduced, and I am firmly convinced, from my own experience, that if the annual taxes were reduced to say £1 a year, the loss to the Government would be infinitesimal, if any. I say this from the fact, that every year I meet with a vast number of cases of men who have not brought their inventions into a thoroughly satisfactory condition of profitable working, and they prefer to abandon the patent sooner than pay these taxes (though believing that their patents are still valuable), but they would have paid the tax, if it had been only £1. The result is the invention, not having been brought to a financial success, is dropped, and it is no longer to the interest of anyone to take it up. These dropped patents are a rock on which many valuable inventions by other parties have been wrecked, as the examiners, of course, refuse any claim which may appear in these patents, even though the abandoned patent may not be strictly workable in the form in which it has been filed.

Second.—Cost of Patent Actions.

The tremendous costs of English courts are proverbial, and patent cases are more costly than others, owing to our Judges, and very frequently the lawyers also, having very little acquaintance with science. The difference, indeed, between the cost of German patent law, and of English is extraordinary. My firm has taken patent cases to the highest court of appeal in Germany, against Krupp of Essen, the Associated Glass Manufacturers of Germany, Siemens & Halske, Deutsche Rheinische Eisenwerke and numerous others, and in nearly every instance (in these four mentioned cases especially) we won against German subjects, and the costs granted were so liberal that our net agents' and lawyer's bill hardly amounted to £15 in any case, and in several instances we never received the bill from my lawyers at all, they being satisfied with taxed costs. On the other hand, in the one or two cases which we have lost, we have been astonished at the very small amount of costs incurred even in fighting to the Supreme

Court of Appeal, nothing approaching what they would have cost in England, while at the same time the decisions were models of scientific accuracy, a striking contrast to the decision in numerous courts that we have taken cases to in Great Britain. Take, for instance, the case against Krupp. The five judges who finally decided the question were a lawyer, a metallurgist, a chemist, and two other highly scientific men. Part of the attack of Krupp was "that the invention, as set forth in the patent, was unworkable." We stated that it was being carried on on a large manufacturing scale in England, and if they would appoint a commission to take evidence there, we could easily prove it. The court at once appointed the metallurgical judge to go across to England, and each of the parties was invited to appoint an expert to go with him or meet him there. The Judge examined the works minutely, with a copy of the patent specification in his hand, cross-examined the employees, etc., in presence of Krupp's expert and the patentee, and asked these to say anything further that they wished. He came back and at once informed the court that it was being largely worked in England exactly as it was in the patent, and therefore that that ground of Krupp's attack failed. Fancy an English judge doing this!

Now in Liverpool, the cotton brokers or a long time groaned under the heavy law costs which were incurred in their litigations, and finally they entered into a combination whereby in all cases they had to refer their trade disputes to an arbitration Court of their own, and there is probably not a single cotton broker in Great Britain that would like to go back to the old arrangement. It is very rarely that these actions cost more than £5, whereas, fought out in a Court of Law, they would probably cost hundreds.

Now if your new organisation can act on this plan or the Chemists in the British Isles would combine together to put all their patent cases to arbitration of a special Court of their own, in a similar way, that Court being empowered to call in an expert as an assessor, and one neutral lawyer or patent agent, if thought advisable, each side being only allowed to bring evidence of fact, and one single advocate, a chemist, lawyer, or patent agent, the cost would be found to be trifling, and the chances of a rightful decision enormously increased. In the German Court of Appeal in patent cases, they pick from among their body (according to my experience) one lawyer, and four scientific men, more or less acquainted with that particular line of science, with power to call in an assessor. Neither side is allowed to call scientific experts, *qua* experts. The Court does this if necessary. The result is that law actions there cost much less in shillings than in England they do in pounds, and the decisions are much more satisfactory. In Germany an ordinary court has no power to judge in a case of infringement or validity of a patent—the matter must be brought before the Patent Office Court, and from that, on appeal, to the Supreme Court of the Patent Office.

Third.—Assessing costs and damages.

In an action in Great Britain, the patentee can either apply for damages assessed on the amount of profit which he can prove he would have made if he had manufactured the infringing articles himself, or the profit which the infringer himself has made on the transactions. In either of these cases he has very formidable difficulties to contend with. If he chooses to take the profit which the infringer has made, the infringer contrives to lessen the amount of profits by an immense bill for experiments, for works charges, oversight, travelling, advertisements, etc., and the costs of proving this are often greater than the costs of the trial in the first instance. I have known of one case which took ten years before the assessment was finally completed, and it ruined the winning party.

If, on the contrary, the inventor applies for the damages to be assessed according to the profits which he would have made on the proved infringements, he has enormous difficulty, first in ascertaining the particulars of these infringements, and secondly, in proving that he would have got each order if the infringer had not taken it. On one occasion where the House of Lords decreed damages in a case in which I was engaged, and in which we elected to take the profits which we would have made out of the infringements, there was, we were satisfied, more than £25,000 profit made. We finally compromised for £5000, finding it impossible to get hold of many of the customers of the infringer, and of getting other customers to admit that they would have given us the order. In several foreign countries there is none of this trouble, as the infringer has to pay the value of the infringing articles, or in some instances two or three times this amount. If some simple arrangement of this nature could be enacted, a vast amount of legal fees and other expenses and also of actual fraud would be obviated. At present, but for the extravagant costs of patent actions, it would always be at least equally advantageous to risk an infringement action as to pay royalties.

Fourth.—Provisional protection.

Except in Great Britain and some of her Colonies, there is no country who has adopted our system of provisional protection, and even some who had adopted it, afterwards abandoned it. In all the rest of the world a complete specification is filed at start, but in nearly all the principal countries additional improvements can be added in a separate application, to date as of the date of such application, but to be covered by the patent.

Provisional protection has been productive of a very large amount of fraud, notwithstanding the efforts of the Patent Office, who have become extremely careful in this matter, and of patent agents, to prevent it, and the only advantages (if advantages there be) in this provisional protection system are two: 1st, that it gives the patent agents and the lawyers a large amount of work, and an opportunity of extracting fees; and 2nd, that a schemer who has thought of an idea but not developed his invention can apply for provisional protection, and so get six months (formerly nine) during which he can work it out, or, if it be in a rather favourite field of invention, find in the meantime what other people are doing, ignorant of his protection, and then cover these other men's inventions in his complete. I will give two illustrations. An inventor came to our firm, and asked us to enter a provisional specification of his own drawing up, in which the member of our firm, who took it in hand, could hardly understand a single sentence. He, however, did not like to take the responsibility of refusal, so filed the application. The Patent Office promptly rejected it, saying it was all rubbish, and he must file a proper specification. At that time there were nine months provisional protection during which he could do this. At the end of about eight months he brought a thoroughly satisfactory specification, and it was allowed as of the original date, and a week or so afterwards brought some excellent drawings and a complete specification minutely describing the invention. Now it so happened that at the time he first called on us, we had in our office an invention of Mr. Edison, the American inventor, the drawings and specification being all made out ready for filing on the day of issue of the American specification (for at that time to file it on

that particular day was very important). Mr. Edison had let it be generally known that he had a very valuable invention for a given purpose, but did not give details to the public—only described what it would do. Our client, therefore, had drawn up this bogus specification, embracing every word descriptive of the invention, which Mr. Edison had published, and if it had not been that he had accidentally come to Edison's own patent agent, who recognised the drawings, he would have obtained the prior rights to Edison's invention. As it was, we refused to complete the patent, or to give up the specification and drawings, but sent the whole account to the Patent Office with full particulars. The Patent Office absolutely refused to allow this man to have a patent. On another occasion a patentee brought me an invention which looked very good, but was too complicated. Near the end of the period of provisional protection he brought a very great improvement on it, and asked whether I could complete the patent on this improvement, instead of on the original design. On examining the provisional specification, I found I had so generally worded it, and had put so many suggestions in it, that it practically covered the new invention about as well as it did the old, and I obtained a patent for him on the new invention. He then came to me and wished me to oppose another man's patent, on the ground that it had been previously patented by himself in the aforesaid specification. I opposed this other man's patent, and got it refused. Afterwards indubitable evidence was obtained, that my client had not invented it at all, but had stolen the invention from the other, who had published his invention a little before my client completed his, and before he came to me with the new invention. Nothing, however, resulted, as the rightful inventor did not care to go to the expense and danger of a suit-at-law. Had the first patentee, in either of these cases, been obliged to file a complete specification at start, as he would have had to do in any other country but a British one, the fraud would have been an impossible one.

Fifth.—Compulsory licences.

By the Act of 1883, any interested person could go before the Board of Trade, and on showing a *prima facie* case that a patent had not been worked in this country during the previous three years as much as it had been worked abroad, the Board of Trade would call upon the patentee to make his defence. A day would be set apart for hearing the parties, when the Board of Trade could decide whether a licence should be granted, or not. This was a very cheap, simple, and satisfactory procedure, but unfortunately it had the very great defect of not putting money into the lawyers' pockets; in fact, in one or more of the first and only cases that were tried under this clause, no lawyer was engaged, or at any rate only on one side. Accordingly a law "for simplifying and cheapening the process" was passed, namely, the applicant had first to prove the matter before the Board of Trade, and then with the latter's consent bring an action before the Privy Council (about the most expensive Court in England). So expensive was this procedure, that no case was decided under it, and the present working clauses are a slight modification of this act, which also have fortunately proved practically unworkable. I say "fortunately," as had they been carried out as anticipated by their author, a man would have had practically to decide whether he would have an English patent without rights abroad or no rights in England. Fortunately a decision of Judge Parker, almost straining the law, saved the situation, as five different countries were passing or had passed retaliatory measures. This Act was passed at the instigation of the Manchester Chamber of Commerce, of which Ivan Levinstein was chairman. Previously many "working" Acts, as they were called, had been passed in other countries but had sunk into desuetude as impracticable. If was sufficient in most countries if the inventors worked them at all, and in one or two only sufficiently to fulfil the reasonable demands of the country.

At the time when these Acts were passed, there were two working laws in existence in other countries, which had given satisfaction. The first was the Swedish one, by which if any interested party proved to the Patent Office, that any patent three or more years after grant was not being worked sufficiently to satisfy the reasonable demands of the country, he and the inventor were heard by the Patent Office (or by the Court after 1902), and such authority could oblige the patentee to grant the applicant a compulsory licence. This was an exceedingly cheap procedure, and has ever since the day it became law, namely, 16th May, 1884, given general satisfaction. The other Act was the present Canadian Act, by which the applicant has the option of either working the invention in the realm sufficient to supply the demands of the country, within two years of grant of the patent, or within six months of grant of putting his patent under the Compulsory Licence Clause, whereby any person applying to the Patent Office, giving him full notice, and satisfactorily proving that the invention was not sufficiently at work and that he was a suitable party, could be granted a compulsory licence on such terms as the Patent Office saw fit, the royalty of course to be paid to the inventor, who was fully heard. The procedure in both instances is remarkably cheap. In both these procedures (Acts) there is an appeal on points of law, but they have the defect of the English Act of 1883, that they bring little or no fees to legal practitioners.

Sixth.—Duration of Patent.

Great Britain has, with the exception of a few smaller countries, the shortest duration of patents of any country, and the tendency in new laws abroad is to extend the time rather than lessen it.

The United States grants patents for 17 years, and without any annual taxes, and there is a project of law before the legislature, to extend the duration. Belgium grants them for 20 years. Most other countries grant them for at least 15. It is found continually that the patent is just beginning to pay well near the end of the 14 years, and in Great Britain we have a costly procedure for extending the life of a patent usually for three to seven years. If the patents were granted for 20 years, as in Belgium and the United States, there would be no need for this procedure, but in that case again, a great field for law charges would be cut off!

Another valuable improvement in force in nearly all countries would be to allow assignees of patents to apply for patents. We can do this in the case of convention patents.

And now a few words on the temporary rules during the war. My firm has applied for compulsory licences for many patents of Alien Enemies, and in every case in Great Britain, in India, and in Australia, where they have the same law, they have been allowed on fair terms, and Mr. Runciman and the Board of Trade have repeatedly intimated that it is their intention to continue these licences for the duration of the patents, but these licences are theoretically liable at any time, even during the war, to be revised or rescinded on good cause, but I am still confident that these licences will continue to the termination of the respective patents.

DISCUSSION.

The PRESIDENT expressed some doubt as to the authority of an official to give a verbal assurance to licencees in regard to the period of their licences. It would have been more satisfactory had some official intimation been given through public channels. He was interested in the suggestion made by Mr. Gordon, which on the face of it had the great advantage of extreme simplicity—that was, that instead of granting monopolies we should grant the power to issue licences. The question of licences would then become a matter of negotiation, and, as Mr. Gordon suggested, the machinery involved for applying for injunctions would be brought into use. In commercial matters Arbitration Courts had very largely taken the place of appeals to Courts of Law, and with very great success. The new Association of Chemical Manufacturers included in its articles the provision that it might have the power to act as arbitrator or to appoint arbitrators.

Mr. A. G. BLOXAM said that our Patent Law came into operation under an Act of James I., dated 1623, and we had never got away from that Act. That was, he thought, one reason why the Patent Law at present was a source of dissatisfaction to chemical manufacturers. One clause in the Act of 1623 which was still on the Statute Book allowed the King to exempt from the iniquitous practice of granting monopolies, monopolies granted for 14 years for new manners of manufacture. In those days it had been very difficult to establish a new manner of manufacture, and from the cases which had been published it would appear that the establishment of a new manner of manufacture then had consisted not in applying an invention made in this country, but in going abroad to acquire knowledge of what others were doing, and applying that knowledge over here. He submitted that we should regard the patent system not only from the point of view of its being advantageous to the inventor in enabling him to start a new industry, but from the point of view of the public. The alternative to a patent system must be secret working. The Patent Law persuaded a man to part with his secret and did away with the trouble which always occurred from secret working. He had been asked recently what would have been our position if the Salvarsan patent had never been published. It might have been difficult to determine the constitution of Salvarsan by mere analysis. It was commonly stated that a patent specification did not disclose the invention. He did not think that was quite just. It was exceedingly difficult to write a specification in any case, and it was almost impossible to compel or even to ask the inventor to put in everything that must be done to ensure the best result. Although there were probably cases in which the specification was not fairly drawn, he thought that those cases were far from being in the majority. Taking the view that the real basis of the Patent Law was the publication of inventions, there was considerable reason in the injunction, for it seemed common justice that the inventor should remain under the same advantage which he would have if he were to work secretly, and that advantage was a monopoly, and not merely a license to grant licenses to others. Mr. Gordon did not, he thought, favour compulsory licences in general, but only as an alternative to the injunction, and one of his reasons was that in the past the application for a compulsory licence had been an intricate and costly operation. Within the past few years it had been found possible even in disputed cases for the Comptroller to constitute a satisfactory Court of first instance. He did not, of course, suggest that he should be the final Court.

Dr. A. RÉE said, looking at the case from the point of view not only of chemical industry but of the public in general, it seemed to him that a patent was granted to an inventor not only for the benefit of the inventor but quite as much for the benefit of the State. That had been the original intention of the Act. He thought we had not sufficiently considered the interests of the State in this matter, and it was the interests of the State more particularly, he thought, that had actuated the Manchester Chamber of Commerce when 33 or 34 years ago they had begun their agitation with regard to the reform of the patent law. At first it was proposed that the procedure in regard to the granting of compulsory licence should be altered, and there were one or two Acts—the last one in 1902—which had given what seemed at the time to be benefits and advantages that might accrue to the British manufacturer and to the State. Unfortunately, legislation carried in those days proposed procedure which was so complicated and so costly that he believed that during a period of something like 20 years up to 1913, only one application for a compulsory licence had been brought into the courts, and that was the case of Mr. Levinstein, who had brought an action for the granting of the compulsory licence, which had proved to be very costly. It had been felt by the Manchester Chamber of Commerce that it was very unfair and unreasonable that the inventor should be put to great expense before he could obtain a compulsory licence, and it had been partly with the view of altering that that the Manchester Chamber of Commerce had begun an agitation in favour of compulsory working. Compulsory working, he believed, obtained in practically every industrial country of the world, with the possible exception of the United States, where high duties rendered it unnecessary. There had been very strong opposition on the part of the patent agents. He believed that one great reason for that was that a much larger number of important patents were taken in this country in respect of chemical inventions by German firms than by English firms. Naturally these foreign firms considered that it was directly opposed to their interests that compulsory working should be introduced into this country whereby they had to manufacture in this country in return for the protection of their invention for fourteen years. It was not until about 1906 or 1907 that they had succeeded (thanks to the quick perception of Mr. Lloyd George) in getting the legislature to realise the position in regard to foreign patents. Mr. Lloyd George had said "*A patent is a monopoly granted by the State for adequate consideration and the State is entitled to see that the adequate consideration is given. It is a very valuable asset which the community gives in return for something it expects, and it is entitled to say that if it has not got its share of the bargain it will revoke the whole of the monopoly which it has conferred.*" That was practically what Section 27 of the Patent Act of 1907 effected. The Mersey Chemical Works and others had been started in order to carry out the provisions of the compulsory working clauses of the 1907 Act, and in several cases, at all events, actual manufacturing had been commenced. He mentioned as an instance the case of indigo. The indigo used in this country up to the beginning of the war and for some months afterwards had been almost exclusively, if not exclusively, produced in this country, at the works of the concern which to all intents and purposes was the German firm of Meister, Lucius, und Brüning. The remarks he had made on the previous day were more particularly in reference to the fact that Mr. Thompson had been in the past and was apparently even to-day in favour of compulsory licences and strongly opposed to

compulsory working. He thought that the question of whether compulsory licences or compulsory working was the best in the interests of the country had been thoroughly thrashed out during the last 8 or 9 years, and he believed that the community generally, including not only business men and manufacturers, but also the great body of working men, realised that compulsory working would mean the bringing of industries to this country and the employment of labour in a large way. If we were going to adhere to or return to compulsory licences—and we had practically returned to-day to compulsory licensing—all that was generally obtained was the paper on which the invention was described. Most of those who had had any experience during the last year or two with regard to patent specifications, especially those dealing with dyestuffs and the intermediate products for their manufacture, had realised that there must be something radically wrong in the way those specifications were allowed to be drawn up. The large German chemical manufacturers employed the greatest skill so to draw up these specifications that the most expert in this country were often unable to carry out the invention even on a laboratory scale. Every inventor naturally felt that he wanted to give away as little of his invention as possible, but if we were going to grant the greatest possible monopoly to a foreigner he should do something in return. How many of the important German patents had actually been worked on a commercial scale in this country for the last 20 or 30 years? Very few indeed. The case of indigo was an exceptional instance, where the firm had not only carried out their legal obligations but had also observed the spirit of the Law. Their directors must have come to the conclusion that it was reasonable for them to do something for the State that granted so great a monopoly. That was, however, an isolated instance. As a rule it took several years before an invention was worked out to such perfection that it could be said to be a success. If for 14 years we gave the foreign inventor permission to carry out his invention abroad only, and not here at all, he thereby practically always secured a permanent monopoly. The compulsory working that was provided for in Section 27 of the 1907 Act would have met the difficulties of the case, and it was most unfortunate that Mr. Justice Parker—now Lord Parker—should have given a decision in 1909 in a case with regard to the revocation of patents, which resulted in the annulling of that Section 27 of the 1907 Act so far as its useful purposes were concerned. Lord Parker had practically decided that before any applicant could obtain a revocation of patent on the plea that it was not worked in this country, he must prove to the satisfaction of the Court that the invention was not worked on an adequate scale in this country. It was impossible to get such proof by anybody who wanted to work the patent unless he chose to go about it in a very disreputable manner. Now, Lord Parker's main plea in that case was, he believed, that it was unfair that the man whom you attacked should be called upon to prove your case; that it was contrary to the principles of the law of this country. There were many cases, some of which Dr. Rée instanced, in which an applicant could call upon the person against whom he was proceeding to prove that he was or was not doing what was alleged. In June, 1914, a deputation of the Association of Chambers of Commerce had waited on the President of the Board of Trade, with a view to induce the Government so to modify the wording of Section 27 of the 1907 Act, that the interpretation of that Section would be the one that had obtained before Lord Parker had given his decision. So far nothing had been done.

Early in the 'nineties his old firm had started the manufacture of aniline colours, and some three or four years after they had started the most powerful firm in Germany had tried to deprive them of the fruits of one of their inventions by upsetting the patent which they had secured in this country. Although they were then a small and unimportant firm their opponents had not succeeded in their endeavours. Later, for working a patented process of producing certain valuable dyestuffs, they had required certain products that had been patented by a German firm in this country, but which the same firm had been unable to patent in Germany. That German firm had refused to supply them with those products, and ultimately, after a lengthy correspondence, the whole case had been submitted to the Board of Trade, and it was largely owing to the evidence they had been able to bring forward at the time to the Solicitor of the Board of Trade that the 1902 Act, or rather those clauses of the 1902 Act that related to the then compulsory licences of a new order, had been passed. Dr. Rée contended that if we could not have something like compulsory working, if no satisfactory substitute could be found—and he was certain that compulsory licensing alone would not do—then in the best interests of this country and particularly of the chemical industry in this country, it would be far better not to have any chemical patents at all.

Professor H. E. Armstrong said that the real subject to be discussed from the point of view of chemical industry was whether or no patents were in any way a help to industry. German manufacturers had long ceased to bring infringement actions against one another in this country. They had realised that they were wasting their money in competing against one another and that they had better pool their forces and compete only against the foreigner. If that condition prevailed formerly when there were two or three groups, now that there was only one group there would be absolute unanimity. The question was whether there should not be an agreement among manufacturers here that they would not fight with one another but combine together. The result would probably be that the Germans would take out very few patents in future but rather tend to secret working, since they were all combined together; they would not need patents as protections against one another and if England insisted on a patent being a complete disclosure of the invention, it would be absurd to take out patents. The late Dr. Mond, he believed, had arrived at the conviction that patents were detrimental to industry rather than helpful. From the point of view of the patent being a complete disclosure of the invention, he ventured to think that Dr. Rée had gone too far in what he had said about the lack of *bona fides* on the part of a large proportion of inventors. What had happened was probably very much what Mr. Bloxam had indicated—there had been difficulty in making a complete disclosure. He contended that an invention was not complete when made and could not be so. To make it complete the patentee should eventually disclose what had been learned in carrying out the invention. As a rule, the inventor was not doing much more than handing on an idea he had got from somebody else and improving it a little, perhaps. The people who often really did the work were the exploiters of the invention, who carried it into practice and made it a commercial success. Another direction in which we should move was in the matter of blocking patents. In developing these undoubtedly the enemy had adopted tactics of extraordinary cleverness. They would not make a direct attack upon an important invention but would study the subsidiary operations and take out patents which stood in the way of development along the lines of these. That was the worst form of interference with patents at the present time; it was very often of far more

consequence in the end than a mere patent for the improvement of the primary invention. He agreed with Dr. Rée that the firm of Meister, Lucius, und Brüning undoubtedly had taken a high moral view of their obligation under our Act, in setting to work to make indigo and other things in this country. Mr. Gordon ought not to have quoted the Levinstein case or at any rate he ought to have quoted it accurately. He said that the Blackley Red was made by a secret process: that statement had been made over and over again but it had never been proved and there was not, in fact, a secret process. He said further that the Badische chemists had been wholly in the dark as to its synthesis but this also was untrue. Having been in the case all through, said Professor Armstrong, the facts were all known to him.

Mr. GORDON, in reply, said that Mr. Reid complained about the revenue which was drawn from patent fees, which he stated amounted to £275,000 a year, and that he regarded as a serious burden on the inventor. Actually it was a small proportion only of the £275,000 that came from the inventors. The great bulk of those fees was paid by patentees whose patents had run for many years. The British system of patents was more liberal in respect of fees than any system in the world, because it granted a patent free from anything in the way of fees except the original application fee of £1, and the sealing fee of £4, for a period of 4 years. It was true that in America the period was longer, but the original fees were much heavier. At the end of four years the renewal fee was only £5, and at the end of 14 years there was a renewal fee of about £50, but it was no hardship to pay such a fee. By the end of that time, if the invention was not of a paying nature it ought to be surrendered in the public interest. Mr. Bloxam had suggested that the injunction was the proper way of protecting a patentee, because the advantage of the patentee under his patent grant ought to be as nearly as possible the same as he would secure if he were successfully working in secret. That did not seem to be self-evident. If an inventor were working his invention as a secret process, he was working it under very difficult conditions. He had to secure secrecy of a very large number of workpeople and others: he had to confide his secret to so many people that the possibility of keeping it a secret for any considerable period imposed upon him a very serious obligation. He was relieved of all that inconvenience by the patent system, and the community got some advantage corresponding to the advantage the patentee got by his patent grant. Therefore the advantage was not necessarily the same under the patent system as it was under the system of secret working. With regard to the view that compulsory licensing did not meet the case and that compulsory working did, Dr. Ree was labouring under this difficulty that the only compulsory working which we had actually in use in this country confessedly, in his view, did not meet the case, and, therefore, when he said that compulsory working would meet the case he was speaking of some other system of compulsory working which at present we had not in operation.

Dr. REE: From 1907 to early in 1909 up to Lord Parker's decision, it worked exceedingly well.

Mr. GORDON: Those manufacturers had started on a certain view of the operation of the law, which was not upheld when the question came to be tested in Court, and the law, of course, was the law that operated.

Dr. REE said that that had happened owing to the careless wording of Section 27.

Mr. GORDON, continuing, said that such things very constantly happened. That complaint was one which lawyers were constantly making about every Act of Parliament. Language was not a sufficiently plastic instrument to express all that was meant. Something which looked the simplest in words often turned out to be the least effective when it was put into use; that, he thought, was the case between compulsory licensing and compulsory working. Compulsory working, he agreed, looked to be much simpler and much more effective, but so far as he knew compulsory working had always proved in practice to be very difficult and very ineffective and very impracticable. He suggested that a Committee of this Society might be appointed to go into the matter. It had been suggested that under a compulsory license one only got the written specification. That difficulty might be overcome by making it a condition that the patentee should also give his personal assistance to the licensee.

Mr. W. F. REID said, with regard to doing away with patents, especially in connection with the chemical industry, that no suggestion could be more injurious to the progress of our industry than the abolition of any reward to any man who might have power to invent new processes or new apparatus. In that event the inventor would not remain in this country but would go to a foreign country where he could get something for his brains and intelligence. In regard to Patent fees, Mr. Gordon had not said that the price for the whole term of the patent was £100 in this country, whereas the same and very much better protection was obtained in the United States for, say, £20. A lot of their trouble and a great deal of expense had been due to the drafting of these laws by men who were accustomed to legal language and who did not know how to express their ideas plainly. If those who really understood the subject were to debate some particular subject of legislation, and the results of their discussion were written down in ordinary language, laws could be produced which would be more satisfactory and more easily understood by the people than those made by Parliamentary draftsmen. The description which Mr. Thompson had given of the simple method prevalent in Germany of deciding these questions, threw great light on the advantages that the German chemical manufacturers had in such matters. In conclusion he quoted the following words of Lord Justice Moulton, "The true remedy is that you ought to protect the monopoly of every inventor who acts reasonably and punish those who act unreasonably. No patent ought to be used for the purpose of checking work in the country itself."

Mr. W. P. THOMPSON, replying to Dr. Rée's contention that a great number of works had been started in consequence of this law, said that the Institute of Patent Agents had gone through those lists, and could find only three or four works that had really been started in consequence of this law. With regard to Mr. Justice Parker's ruling, what he had said was that no one had a right, unless he could give really good *prima facie* evidence that there was a good case, to force any man into the box and have his whole business brought to the public notice; and that therefore the other side must give a reasonable and good *prima facie* case, and since then there had been none brought forward. Nothing had been said in answer to his contention that compulsory licensing was sufficient. In some countries in which there had been compulsory licensing everybody had been satisfied. At the present time there was hardly a country, with the exception of Russia, where an invention could not be officially worked for from £5 to £10, and especially in the case of France and Belgium.

THE PROGRESS OF THE BRITISH RARE EARTH INDUSTRY DURING THE WAR.

BY SYDNEY J. JOHNSTONE, B.SC. (LOND.)

Under the term "Rare Earth Industry" is included the manufacture and utilisation of certain of the so-called "rare earths," the more important of which are thoria and ceria, whilst those in less demand include the oxides of didymium, zirconium, and tantalum.

Thorium salts. The most important of the industries depending entirely on an adequate supply of thorium nitrate is the manufacture of incandescent gas mantles. These consist essentially of a fabric of ramie, artificial silk, or cotton, impregnated with a solution consisting principally of thorium and cerium nitrates in the ratio of 99 to 1, certain other inorganic salts being used to harden the ash skeleton. It is unnecessary, however, to discuss here the nature and function of these latter salts or the process of making mantles.*

The British industry has undergone several extreme changes during the past two years, varying from a serious shortage of most of the necessary raw materials at the outbreak of war to the present position, which is full of promise for our future independence of foreign raw materials.

During 1913, the estimated consumption of incandescent gas mantles, in the United Kingdom amounted to about one hundred millions, and of these probably about sixty millions, valued at nearly £200,000, were imported from Germany. In addition, thorium nitrate to the value of £41,544 was also imported.

More than 10 years ago certain firms in Germany obtained a monopoly of the most important deposits of monazite sand, the raw material from which thorium nitrate is produced. As a consequence they were able to control the thorium nitrate market, and the United Kingdom was thus almost entirely dependent on German supplies of the salt. The importation of thorium nitrate from Germany ceased on the outbreak of war, and prices in the United Kingdom rapidly rose from 22s. to about 75s. per kilo., one firm being able to dispose of its stock, held in reserve for such contingencies, at 90s. per kilo. Those incandescent mantle makers whose reserve supplies of the salts were small were thus faced with an early stoppage, as little was obtainable from France, and practically none from the United States, and the only possible sources in the United Kingdom were waste mantle ash and a small quantity of monazite sand.

This serious shortage of thorium nitrate led British chemical and incandescent mantle manufacturers to look into the question of obtaining adequate supplies of monazite sand in order to make thorium nitrate in this country.

The only known deposits of monazite sand of any commercial importance are those worked on the coast of Brazil and in Travancore, India, the latter sand being of considerably greater value on account of its higher content of thoria.*

For several years prior to 1914, however, the whole of the output of monazite sand from Travancore, amounting to 1300 tons per annum, and equivalent to at least 2300 tons of the best grade of Brazilian sand, had gone to Germany for treatment. The lease for working these deposits had been granted to the London Cosmopolitan Mining Company by the Travancore Durbar with the approval of the Government of India. This concession was limited to the extent that its transfer could only be made to a British Company. Shortly after the concession was granted the Travancore Minerals Company was formed to work the deposits, and the Company contracted to sell the whole of its output to a German firm. An investigation made soon after the outbreak of war showed that the whole of the Preference shares and 11,000 of the Ordinary shares in the Travancore Minerals Co. were held in trust for the Auer Gesellschaft of Berlin. After consideration, the Secretary of State for India decided that certain conditions must be observed in the future working of the Company, the principal of which is that all seven Directors must be British born, one of whom is to be nominated by the Secretary of State for India, who may also direct his election as Chairman. The voting rights of the enemy shareholders were reduced, the capital increased from £40,000 to £100,000, and the British holding increased, and the German contracts cancelled. These restrictions are of importance for insuring that the control remains in the hands of British born subjects, but a further condition is of vital importance to the industry. It has been embodied in the following undertaking which has been accepted by the shareholders in respect of future transactions *:—

"The Company will be ready at all times to sell monazite sand direct and at a fair price to any *bona fide* British firm that may desire to purchase the material in reasonable quantities for the purpose of manufacture. The Company further undertake that they will give no preference in the matter of price to any purchaser or purchasers of very large quantities, but that the price per ton for all purchases of lots of 10 tons and upwards shall be the same, free at the mine. The Company clearly understand that if in the opinion of the Secretary of State for India, the control of the Company has passed, at any time, out of British hands or if, in the Secretary of State's opinion, there is grave danger, at any time, of British control being lost or jeopardised, or in the event of any breach of this undertaking, power is reserved to cancel the concession."

In addition to the above Company a second one, called Thorium Ltd., has recently obtained a 20 years' lease to work 150 acres of land in Travancore for monazite sand, the royalty payable being £3000 per annum. This Company is now actively engaged in exporting the sand and converting it into thorium nitrate at their works near London.

The other commercial sources of raw monazite sand are those situated on the coast of Brazil and in the interior of Minas Geraes, Espirito Santo, and Rio de Janeiro. The coastal deposits have been worked for many years past and yield a sand which, when concentrated, contains from 4 to 6% of thoria. The right to work these deposits is periodically offered for tender and for many years past the concessions to work the greater number of the important deposits have been held by members of the German thorium ring.

Each of the Brazilian States has a separate export duty on monazite sand, that of the Federal Government which controls all the coastal deposits being 50% *ad valorem*.

The quantity of monazite sand exported has gradually decreased during recent years from 6462 metric tons in 1909 to 1437 metric tons in 1913. Later returns are not available.

There is reason to believe that, prior to the war, the cost of production of Travancore monazite sand containing 8·5 to 9% of thoria did not exceed £4 per ton f.o.b. This material was resold in Germany at about £36 per ton.

During the past year, a considerable quantity of Travancore sand has gone to the United States for

* See "The Rare Earth Industry," 1915, Crosby, Lockwood and Son, London, page 19).

* Monazites from some New Localities," this J., 1914, 33, 55, and "Bulletin of the Imperial Institute," 1911, 9, 103.

* Journal of Gas Lighting, 1915 131, 284.

treatment, and many of our incandescent mantle manufacturers have had to depend recently on supplies of thorium nitrate from this source.

It is satisfactory, however, to record that at least four British incandescent mantle manufacturers are making thorium and cerium nitrates, from Travancore sand, in sufficient quantity for their own present requirements.

If we assume that the quantity of mantles used in the United Kingdom during a normal year is one hundred millions, and that each contains on the average 0·5 grm. of thoria, then the annual consumption of Travancore monazite for this purpose would be about 650 tons, assuming 8·5 % of thoria in the sand and a recovery of 90 %. It is evident, therefore, that the incandescent mantle trade in the United Kingdom is not able, at present, to utilise the thorium nitrate obtainable from a normal year's output from Travancore, and that we must either make a strong bid for a very large share of the world's thorium nitrate and incandescent mantle trade, or see these important resources of monazite sand within our Empire utilised by other nations.

As regards the price charged for thorium nitrate imported from abroad since the outbreak of war, late in 1914 it could be purchased from France at 60s. per kilo., which price was soon reduced to 37s. 6d., but supplies from this source are now practically unobtainable. Large quantities of the salt have been imported from the United States, and in the early part of 1916 contracts could be placed at 40s. During the past month, however, 70s. to 80s. has been asked on new contracts, and delivery could not be guaranteed until October at the earliest.

The effect of the shortage of raw material shortly after the outbreak of war was not noticeable to the general public, as enormous quantities of incandescent mantles were imported from Holland, but it was evident that they were largely German produce re-packed or branded in Holland. A number of the more important incandescent mantle manufacturers brought these facts to the notice of the Foreign Trade Department of the British Government, and an expert was appointed to inquire into the matter. As a result of his inquiries, and the enforcement of the order prohibiting the import of goods containing more than 25 % in value of raw material of enemy origin, a number of consignments were condemned. The quantity imported from Holland has now been reduced to a more normal amount. As that country in ordinary times does not produce sufficient gas mantles to supply a fraction of her own consumption, it is difficult to see how any considerable quantity of mantles made in the country and satisfying the above conditions as to origin of raw material could be available for export. It is probable that attempts will be made to get German-made mantles into this country during the war through other channels.

British incandescent mantle makers, on the whole, report that they find it is difficult to keep pace with all the home trade offered, in spite of the reduced consumption for public lighting. Several state that their export trade, particularly to the British Colonies and to South America, has very largely increased.

There are several other substances, such as ramie yarn, artificial silk, beryllium nitrate, fire-clay rings and supports, into the composition of which the rare earths do not enter, but which are of more or less vital importance to the incandescent mantle industry and, therefore, are worthy of brief mention.

According to several manufacturers, supplies of suitable ramie yarn are difficult to obtain, and the price has been more than trebled since the outbreak of war. Supplies of artificial silk are, on the other hand, at present adequate, but the price has been considerably increased.

As regards beryllium nitrate, which is a constituent of the thorium solution used for impregnating the mantles, a considerable shortage was experienced by several firms late in 1914, but the Imperial Institute was able to indicate where supplies of the salt could be obtained, and it is understood that supplies are now obtainable from British chemical manufacturers. The price, however, has been considerably increased.

Fire-clay rings and supports were largely imported in the past by German controlled firms, but it is now possible to obtain supplies of these of good quality manufactured in the United Kingdom by British firms.

There are several industries which use small quantities of thorium, the most important of which is the manufacture of filaments for certain electric glow lamps. These filaments, which consist essentially of an alloy of tungsten and thorium, were formerly imported from Germany, but it is understood that they are now being made in large quantities in this country.

Cerium earth compounds. These are obtained by treating the residue resulting from the extraction of thoria from monazite, and are employed in the manufacture of incandescent mantles, optical glass, pyrophoric alloys, and carbons for "flaming" arc electric lights.

Pure cerium compounds, suitable for use in the manufacture of incandescent gas mantles and optical glass, can be obtained in adequate quantity from British chemical manufacturers. There is, however, a fair quantity imported from the United States.

Prior to the war pyrophoric alloys were made in this country by a firm of German association from a partly manufactured material imported from Germany, but, so far as information is available, the manufacture of these alloys has not yet been started by any British firm, the present supplies coming from the United States.

Carbons for "flaming" electric arcs containing cerium salts were produced by several British firms prior to 1914.

By an Order in Council dated February 23rd, 1916, the export of the oxide and salts of cerium, metallic cerium, and its alloys, except ferro-cerium, was prohibited to all destinations. The export of ferro-cerium (cerium pyrophoric alloy) was prohibited to all destinations abroad, except to British Colonies and Protectorates.

Didymium salts, which are obtained from the same source as cerium and are used for branding incandescent mantles, are being imported from the United States, but the consumption of these is small.

Tantalum. There has been no shortage of the raw material, the mineral tantalite, and it is reported that the pure metal is being made by one firm at least in the United Kingdom for the production of filaments for electric glow lamps.

Zirconia. This substance, which has been much advertised by the Germans as a refractory material, is not being prepared in useable form in this country, the small demand being met by imports from the United States.

It will be seen that in the past this country has had to depend largely on foreign countries for its supplies of a number of articles into the manufacture of which the rare earths enter, and even in the cases where the article was made in this country the manufacturers had to depend almost entirely on foreign countries for supplies of partly manufactured material. There does not appear to be any reason why this state of things should again prevail after the war. All the necessary raw materials are available in adequate quantities within the British Empire, and most of the diffi-

culties in converting the raw materials into appropriate form have been surmounted. The conditions arising out of the war have rendered it necessary for us to commence the manufacture of our supplies, and it is to be hoped that the great progress already made will be continued.

It is quite certain that the powerful German firms who, prior to the war, exercised such a considerable control over the lighting industry, both as regards incandescent gas mantles and incandescent electric lamps, will not accept, without a struggle, the position created by British enterprise during the war. These new British industries may therefore require Government assistance, either direct or indirect, to maintain their position when peace is declared. In that connection it is important to remember that there is no reason to suppose that Germany has exhausted her reserve supplies of Brazilian monazite stored before the war, and even when these are used up she will still hold the concessions to work large deposits of the mineral in Brazil until 1927.

Discussion.

Professor H. Louis said that about three months ago he had returned from an investigation of the Indian monazite deposits, conducted under the ægis of the India Office. There was no doubt whatever but that Britain would now keep a firm hold on these raw materials, and there was no longer reason to fear German competition in that connection in the future. It was not correct to say that Thorium Limited was actively engaged in exporting the sand, and converting it into thorium nitrate at their works near London, seeing that when he had left India about three months ago they had not even commenced to put up their works. It was also incorrect to say that, prior to the war, the cost of production of Travancore monazite sand containing 9% of thoria did not exceed £4 per ton f.o.b. That was a great under-estimate. He had the correct figures but was not at liberty to give them. The passage in which Mr. Johnstone pointed out that the whole of the preference shares and 11,000 of the ordinary shares in the Travancore Minerals Company were held in trust for the Auer Gesellschaft of Berlin, was perfectly correct. The original Monazite Company had been unable to get money in this country to develop these deposits, so that they had had to go to Germany. German engineers had been sent to investigate the deposits, and to find out whether they warranted the advance of money; when they had been assured on that point they advanced the money required, stipulating that they should have the control of the products. The fact that those interested in Britain had been too shortsighted or too timid even to investigate the proposition had given the Germans an opportunity that they had been shrewd enough to utilise. Once again British apathy had been Germany's opportunity. The question of raising funds for this new industry opened the very much wider question of the attitude of the banks towards industry. When British industry had commenced to develop, about 100 years ago, the greater part of the banking in this country had been in private hands, and any one who went to private banks for assistance with a sound story was able to get the assistance he needed. It was very difficult to over-estimate, and very few people adequately recognised, how much the industries in this country owed to the great private Bankers at that period. Since then banking had passed into the hands of limited companies. The manager of a British limited bank had to act like a prudent trustee, and must, so to speak, confine himself to trustee investments. He dared not speculate or risk other people's money as freely as a private banker could risk his own money. In Germany, on the other hand, where the German banker was not restrained by public conscience and was not guided by private tradition, a very different state of things prevailed. In Germany industrial banks were the order of the day, and whereas the German industries could get all the support they wanted from their banks, support of that kind was not to be obtained in this country. Personally he would be exceedingly sorry to see any change in the general trend of British banking, but he saw no reason why, alongside our excellent banking system, there should not be a new system of industrial banking which would make its specific object the supporting of industries, and he did not think that the new Association of Chemical Manufacturers could do any more important or any more valuable work than to consider how a bank of that kind could be formed. To support chemical industries in this country by Government money was a great economic blunder. It would lead to the private financiers getting the good things and the Government the bad ones, and the public would have to pay.

Mr. Johnstone pointed out that Germany had monazite concessions in Brazil, which would last another 10 years or so. The monazite deposits in British India were between two and three times as rich in thorium as the Brazilian deposits, so that we need not fear this competition very much. Furthermore, he had seen it stated on good authority that a French Company had succeeded in securing the pick of the Brazilian monazite concessions. That company was now working the Brazilian monazite beds, and extracting thorium nitrate from them, and he had been told that those deposits were much richer than those controlled by the German interests. Therefore it would appear that in Brazil as well as in India Germany stood a very poor chance of maintaining any hold upon the raw material mainly required for this industry.

Mr. Thomas Tyrer agreed with Professor Louis' statements, and said that the subject of industrial banks was not only worthy of consideration but was now being considered by some of the finest financial experts in London.

The President said that the thorium difficulty had come before the company with which he was connected, and one of their engineers had been sent to South America to obtain some supplies of sand. After spending some time there, and going over a good deal of the coast, he had found that impossible. Later on, they had been offered an interest in some deposits in Carolina, and in that case they had secured the services of a qualified expert, who was highly recommended by the proper authorities. In the end it had been decided that he should go himself to visit the mine. It was a wonder to him that any man calling himself a mining expert should have recommended that place to be developed.

INDUSTRIAL ALCOHOL.

The President then proposed that, in order to give effect to Mr. Reid's suggestion, the meeting pass a resolution authorising the Council to take such action in the matter as they might deem necessary, and suggested that the resolution might be in these terms:—"Having regard to the great importance of alcohol in developing manufactures at present carried on outside the Empire, the Council of this Society be empowered to take such steps as they deem necessary to obtain relief from the present restrictions."

Mr. Tyrer seconded the resolution, which was carried unanimously.

Vote of Thanks to the President.

Dr. Ree referred to the highly efficient way in which Dr. Carpenter had conducted the affairs of

the meeting. No man could have conducted the business in so fair and reasonable and pleasant a manner. Everything that Dr. Carpenter had done, he was sure, had met with the approval of the members. He proposed a very warm vote of thanks for what the President had done for the Society in the past and for what he was sure he was also likely to do in the future.

Professor LOUIS seconded the motion, which was carried with acclamation.

VISITS TO WORKS.

On Friday afternoon, the works of the Pumpherston Oil Company, the North British Rubber Company, and Messrs. McVitie and Price's Biscuit Factory were thrown open to members, by the courtesy of the directors. A large number of members availed themselves of the privilege thus afforded, and the visits proved to be of a most interesting character.

EXHIBITION OF DYES, GLASS, PORCELAIN, ETC.

During the meeting there was on view an exhibition of dyes, glass, porcelain, etc., arranged in a large room in the University Union. The primary object of the exhibition was to indicate the progress that had been made since the outbreak of war in the production of these substances, the greater part of the supply of which had previously been obtained from Germany and Austria. Many of these products had not been made in this country prior to the war, while in other cases the progress made is represented by greatly increased output. In addition to the above mentioned, there were interesting exhibits of some of the products of local industries.

A list of the exhibits is given below :—

Section I.—Coal tar dyes.

Messrs. Levinstein, Ltd., Blackley, exhibited a large range of raw and intermediate products, chrome dyestuffs, sulphide dyestuffs, leather dyestuffs, direct dyestuffs, vulcan dyestuffs, and acid dyestuffs.

British Dyes, Ltd., of Huddersfield, also showed a number of intermediate products and dyestuffs, including synthetic phenol and trinitrotoluol.

The British Alizarine Co., Ltd., of Silvertown, exhibited a comprehensive collection of specimens illustrating the manufacture of anthracene dyestuffs. These ranged from crude anthracene and anthracene derivatives to anthraquinone and its derivatives and various anthracene dyestuffs, some of which were shown in solution. Specimens of acridine, chrysene, carbazole, madder root, madder in powder, and garancine were also shown.

Section II.—Glass.

Messrs. Baird and Tatlock, Ltd., London. Beakers and flasks of "Duro glass," also flasks, beakers, Petri dishes, gas shades, mantle protectors, and test-tubes.

Messrs. John Moncrieff, Ltd., Perth. A variety of flasks, beakers, gas jars, crystallising basins, test-tubes, and tubing.

Messrs. Wood Brothers, Barnsley. Flasks, beakers, potash bulbs, graduated burettes and pipettes, and Nessler glasses, in ordinary and high-resistance qualities.

The Edinburgh and Leith Flint Glass Co., Edinburgh. Soft soda glass, X-ray soda tube and bulb, blue enamel rod, platinum enamel rod, "shell" glass for eyes, blue cane, opal glass, glass tube, blue rod, bulbs, stemming tubes, flange tubing, crystal tube, and clear glass rod.

Messrs. James Powell and Sons, London. Specimens of round and triangular enamelled tubes for thermometer glasses.

Messrs. Chance Brothers and Co., Ltd., Birmingham. Specimens of heat-resisting glass globes for high-pressure lamps.

The following notes were contributed to the catalogue of the Exhibition by Mr. R. B. Pilcher, Registrar and Secretary of the Institute of Chemistry :—

The exhibits of glass indicate the progress made by British firms, since the outbreak of war, towards securing a supply of laboratory apparatus and other kinds of glass, enamels, etc., for various purposes, for which we have hitherto been dependent on foreign sources. All of the exhibitors have had the advantage of collaborating with chemists who have given special attention to the chemical constitution and physical properties requisite for satisfactory production.

The initial problems of deciding the formulas for batch mixtures, and of determining the conditions for successful manufacture. have been solved by investigations involving not only the analysis of known glasses, and numerous experimental melts, but the determination of suitable substitutes for constituents not readily obtainable. Many of the exhibits have been made from formulas resulting from the work of Professor Herbert Jackson and Dr. Thomas R. Merton, of King's College, London, working in conjunction with the Glass Research Committee of the Institute of Chemistry, appointed in October 1914. The variety of glasses dealt with covers the wide range shown in the schedule given on p. 815. Since October 1915 the Committee has pursued its investigations with the assistance of grants received from the Advisory Council on Scientific and Industrial Research.

The production of laboratory glass, however, necessitates not only the acquisition of suitable formulas, but provision of materials, moulds, plant, and skilled labour, so that the firms which have contributed, under the stress of prevailing circumstances, to the results achieved, deserve great credit for their enterprise and every encouragement from the users of such apparatus.

The "Report of a Sub-Committee of the Advisory Committee to the Board of Trade on Commercial Intelligence with respect to measures for securing the position, after the war, of certain branches of British Industry" (Cd. 8181) and "Summaries of Evidence" (Cd. 8275) taken by a Sub-Committee of the same Advisory Committee, indicate that the manufacturers have had to cope with very great difficulties, especially with regard to skilled labour, the cost of which represents about 90% of the total cost of production. It appears also from the evidence that manufacturers are apprehensive of competition from German and Austrian dumping, and they have suggested that a tariff duty of 25—30% *ad valorem* should be imposed for five years after the war.

At the instance of the British Science Guild, about 75% of the Universities, technical institutions, and schools have undertaken not to purchase chemical glassware of foreign manufacture for a period of three years after the war, provided that an adequate supply of British manufacture is forthcoming at a price that is not prohibitive. Chemists are urged, therefore, to insist on being supplied with British made glass.

Laboratory Glassware, Miners' Lamp Glasses, X-Ray Tubes, etc.

The following is a list of the formulæ for laboratory glassware, etc., prepared by Professor Herbert Jackson and Dr. Thomas R. Merton, working in conjunction with the Glass Research Committee of the Institute of Chemistry, with notes as to firms working these and similar formulæ.

Formulas prepared between October, 1914 *and October,* 1915.

Formulas.	Firms working to formulas.
1. Soft glass, suitable for ordinary chemical laboratory ware. (Since modified ; *see* No. 13 below.)	
2. A similar glass for ordinary chemical laboratory ware.	Messrs. Wood Bros. Glass Co., Ltd., Barnsley.
3. Resistant glass suitable for pharmaceutical purposes, ampoules, etc.	Messrs. John Moncrieff, Ltd., Perth, and Messrs. Wood Bros. Glass Co., Ltd., Barnsley.
4. Glass for combustion tubing.	
5. Ditto.	Messrs. John Moncrieff, Ltd., Perth.
6. Miners' lamp glasses.	Have been made by Messrs. John Moncrieff, Ltd., Perth, and approved by Home Office.

(NOTE.—Messrs. Ackroyd & Best, of Morley, Yorks, are now making miners' lamp glasses.)

7. Ditto.	
8. Resistance glass.	

(NOTE.—Messrs. John Moncrieff, Ltd., of Perth, are making a similar glass to the formula of the British Laboratory Ware Assoc.).

9. Alternative for combustion tubing.	
10. Soft soda glass, suitable for tubing and X-ray bulbs.	Messrs. James Powell & Son, Whitefriars Glass Works, London, E.C. Messrs. Frank Tomey & Co., Borough Flint Glass Works, Victoria Road, Aston, Birmingham. Messrs. Wood Bros. Glass Co., Ltd., Barnsley.
11. Ditto. (Alternative, *see* No. 14 below.)	
12. Lead glass suitable as an enamel for sealing platinum into soft glass.	The Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.
13. Soft glass suitable for ordinary chemical laboratory ware. (Alternative to No. 1.)	Messrs. John Moncrieff, Ltd., Perth ; and Messrs. Wood Bros. Glass Co., Ltd., Barnsley.

(NOTE.—Messrs. Baird & Tatlock (London) Ltd., are making laboratory ware from glass closely resembling this formula.)

14. Soft soda glass of fine working quality and suitable for tubing X-ray bulbs, etc. (Alternative to No. 11.)	Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.

Formulas prepared since October, 1916—*under Grants from the Advisory Council on Scientific and Industrial Research.*

(I.) 15. Blue enamel for sealing metallic wire into glass.	The Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.
(II.) 18. Opal glass which does not lose its opal character on repeated working in the blow-pipe flame.	The Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh. Messrs. James Powell & Son, Whitefriars Glass Works, London, E.C. Messrs. Frank Tomey & Co., Borough Glass Works, Victoria Road, Aston, Birmingham. Messrs. Wood Bros. Glass Co., Ltd., Barnsley.
(III.) 16 and 17. For the manufacture of electric light bulbs.	Messrs. Wood Bros. Glass Co., Ltd., Barnsley.
(IV.) 19 and 21. High temperature thermometer glass and ordinary temperature thermometer glass.	Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh. Messrs. James Powell & Son, Whitefriars Glass Works, London, E.C. Messrs. Frank Tomey & Co., Borough Glass Works, Victoria Road, Aston, Birmingham.
(V.) 20. Leadless opal glass suitable for working with certain thermometer glasses to form the enamel backing.	Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh. Messrs. James Powell & Son, Whitefriars Glass Works, London, E.C. Messrs. Frank Tomey & Co., Borough Glass Works, Victor Road, Aston, Birmingham.
(VI.) 22. Glass of the same physical properties as fluor crown. (6781)	Messrs. Wood Bros. Glass Co., Ltd., Barnsley

(NOTE.—Messrs. Chance Bros. & Co., Ltd., Birmingham, will probably make this glass in the near future.

(VII.) 23. Glass having optical properties and chemical composition similar to one known as "Prism Crown."	Messrs. Wood Bros. Glass Co., Ltd., Barnsley.

(NOTE.—Messrs. Chance Bros. & Co., Ltd., Birmingham, make similar glass.)

VIII.) 24. Glass similar in optical properties and chemical composition to a glass described as a "Heavy Flint."	Messrs. Wood Bros. Glass Co., Ltd., Barnsley.

(NOTE.—Messrs. Chance Bros. & Co., Ltd., Birmingham, make similar glass.)

(IX.) 25. Glass for the "shell" of artificial human eyes.	Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.
(X.) 26. Ruby glass suitable for making veins in artificial human eyes.	Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.
(XI.) 27. Glass suitable for making the lens of an artificial human eye.	Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.
(XII.) 28. Soft glass suitable for filling in brass caps of incandescent electric lamps.	Messrs. A. C. Cossor, Ltd., 59, Clerkenwell Road, E.C. Edinburgh & Leith Flint Glass Co., Norton Park, Edinburgh.

Formulas recently reported and about to be communicated to various firms.

(XIII.) 29. A new enamel glass suitable for sealing in various metallic wires including copper, iron, and nickel. This enamel glass makes a satisfactory joint with soft soda glasses and with many lead glasses.

(XIV.) 30. A modification of "eye shell" glass. (Alternative to IX.—25).

(XV.) 31. A formula for an opal glass intended for small electric bulbs with opal backing. A bulb blown from the glass remains clear on cooling, but can be "struck" opal by re-heating to a lower temperature. By heating the front part of the bulb to a rather higher temperature this portion goes clear again and remains so, thus leaving an opal reflecting back.

XVI.) 32. A formula for a batch mixture suitable for making a white bottle glass.

XVII.) 33. Two formulas for lead glass of high density, such as is required for efficient X-ray shields. It is considered necessary that sheet glass for this purpose should have a specific gravity of not less than 3·8.

Section III.—Porcelain.

Messrs. Doulton and Co., Ltd., London. Basins, crucibles (including Gooch and Rose crucibles), combustion boats, filter discs, Büchner and Hirsch funnels, capsules, spatulas, staining troughs, scalpel supports, water bath rings and covers, desiccator plates, acid dishes, filter baskets, wax embedding troughs, mercury troughs, steam jacket for Beckmann's boiling-point apparatus, ash trays, bee-hive shelves, test-tube draining stands, arsenic plates, arsenic porous pots, and anaërobic boxes.

The Worcester Royal Porcelain Co., Ltd., Worcester. Basins, combustion boats, crucibles (ordinary, Gooch, Liebig, and Rose), capsules, casseroles, Büchner funnel, filter discs and cone, pneumatic troughs, combustion and pyrometer tubes, unglazed tube.

Section IV.—Filter papers.

Messrs. W. and R. Balston, Ltd., Maidstone. Ten grades of Whatman's filter paper, equivalent to C. S. and S. Nos. 575, 589 (white, black, and blue ribbons), 595, 597, 598, 602, and 604, and Dreverhoff 207).

Messrs. H. Allnutt and Son, Maidstone. Samples of commercial filter paper.

Messrs. Evans, Adland and Co., Ltd., Winchcombe. White filtering circles (equivalent to C. S. and S. Nos. 595, 597, 598, 602, and 604), grey circles, embossed white circles, crinkled grey circles.

Section V.

British Laboratory Ware Association, Ltd., London. Glassware: Beakers, flasks, funnels wide-neck bottle, tapered adapter, glass tubing. Porcelain: Crucibles and lids, including Gooch and Rose crucibles, capsules, boats, casseroles, porcelain for the dyeing industry, for cooking, and for gas and electric furnaces, steel analysis, etc. Porous ware for battery and bacteriological purposes; fireproof ware for electric furnaces and electrical purposes generally. Pure nickel vessels: crucibles and lids, evaporating basins, capsules, spatulas. Filter paper and other filter goods. Whatman filter papers.

Section VI.

Mr. R. Maclaurin, of Stirling, exhibited various products of his low temperature coal distillation process, in which no external heating is employed. Combustion is maintained by an air and steam blast, and the heat is supplied by cooling the power gas. Each piece of fuel is fully 24 hours in attaining a temperature of about 750° C. Provision is made for removing the oils condensing on the upper layers of fuel, so that practically no decomposition takes place.

The exhibit consisted of samples of the smokeless fuel; crude oils; oils separated by treatment with sulphuric acid and with paraffin oil; oil free from resin and cresylic acid, for lubricating; cresylic oil; resinous portion and varnish extracted from this by turpentine; bitumen from resinous portions; light spirit from the oil.

Section VII.—Shale oil.

The Broxburn Oil Co., Ltd., sent specimens of shale, crude oil, ammoniacal liquor, motor spirit, shale spirit, lamp oils, lighthouse oil, "marine sperm," fuel or gas oils, lubricating oils, miners' paraffin, paraffin wax and candles, ammonium sulphate, and still coke.

Section VIII.—Alkaloids.

Messrs. T. and H. Smith, Ltd., Edinburgh, exhibited five different varieties of opium, as well as morphine and its hydrochloride; hydrochlorides of ethylmorphine and diacetylmorphine; codeine; cryptopine; gnoscopine; narceine; narcotine; papaverine; xanthaline and its hydrochloride and nitrate; meconic acid; caffeine; theobromine cantharidine; salicin; veratrine; emetine hydrochloride; cotarnine hydrochloride.

Section IX.

The Lothian Chemical Co., Ltd., Edinburgh. Specimens of trinitrotoluene, cake, lump, and pure recrystallised from alcohol.

The Beaverhall Colour Co., Edinburgh. Cobalt blue, manufactured from Canadian ore.

North British Rubber Co., Ltd. Specimens of erasers.

Section X.

Messrs. T. Morson and Son, Ltd., London. A sample of Roy's glass filter cloth for the filtration of corrosive liquors. (See this J. 1915, 538.)

Obituary.

NICHOLAS HENRY MARTIN.

Mr. N. H. Martin was born at Trebarveth, Cornwall, on May 2, 1847. From 1863 to 1875 he was engaged in various pharmacies in Cornwall, London, and Hitchin, and passed the examination of the Pharmaceutical Society in 1868. In 1875 he went to Newcastle as partner with Dr. H. B. Brady, F.R.S., and on the retirement of the latter eighteen months later he acquired the business of which he was senior partner and director for forty years, and which, under the style of Brady and Martin, acquired a high reputation for scientific pharmacy, and for the supply of pure chemical products and scientific apparatus. He was one of the first to produce gland extracts, which have proved to be such valuable curative agents, and adrenaline was a feature among his productions.

He held a very high position in British pharmacy, and had served on the Council of the Pharmaceutical Society and as President of the British Pharmaceutical Conference. He was also very keenly interested in chemical industry and sat on the Council of this Society for many years, as Chairman of the Newcastle Section, Ordinary Member, and Vice-President, and had been a member of the Publication Committee since 1899. He was Chairman of the Pharmaceutical Section of the International Congress of Applied Chemistry in London in 1905. Martin was a Fellow of the Royal Society of Edinburgh and of the Linnean Society, a Vice-President of the Natural History Society of Northumberland, Durham, and Newcastle, and a Justice of the Peace for Newcastle and also for Durham County.

He died on July 5th, at his residence, Ravenswood, Low Fell, Gateshead, after a severe illness, at the age of 69.

EDWIN W. WHEELWRIGHT.

Dr. Edwin W. Wheelwright was born at Shipley, Yorkshire, on Sept. 11, 1868, and died at Malvern on May 2nd, 1916. He was educated at the Salt School, Shipley, the Yorkshire College, Leeds, and Balliol College, Oxford, where in 1891 he took his degree. He then studied under Prof. von Baeyer and Bamberger, and on his work on the diazo-compounds obtained the very rare honour of Ph.D. (*Summa cum laude*). After acting as demonstrator at Balliol, he entered in 1893 the firm of Messrs. Albright and Wilson, of Oldbury, near Birmingham, as research chemist, in which capacity he acted up to the time of his death. He was a great authority on phosphorus and its compounds, and match compositions, a position that he owed to his own researches continued over a long period of years. As a technologist his distinguishing aptitude was in taking processes from the laboratory into the works; this was all the more remarkable as he had little or no instinct for engineering.

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Manchester Section.

Meeting held at Grand Hotel, on Friday, March 3rd, 1916.

MR. J. H. HOSEASON IN THE CHAIR.

A NOTE ON THE CHROMIUM INTENSIFICATION PROCESS.

BY R. E. CROWTHER.

The so-called "Chromium" process of intensification of silver photographic images came into prominence in 1905 when Welborne Piper and D. J. Carnegie published important details arrived at by the modification of the original formula of Eder (1881).

The process comprises two operations (exclusive of washings), viz., "Bleaching" and re-developing, and according to the constitution and time of action of the "bleaching" bath, more or less intensification may be obtained.

The following formulæ were recommended :—

	A.	B.	C.	Eder's.
Potassium bichromate ...	1 grm.	2 grms.	2 grms.	2 grms.
Hydrochloric acid (1·16 sp. gr.)	0·2 c.c.	1·0 c.c.	4·0 c.c.	6·0 c.c.
Water to	100 c.c.	100 c.c.	100 c.c.	100 c.c.

Bleaching with bath A yields the greatest intensification, baths B and C yield progressively less, whilst the use of Eder's bath effects very little increase of density of the image. The working details of the process and the copious notes of the two authors above referred to leave little to be desired as far as the application of the process is concerned, but the chemical reactions which lead to the excellent and permanent results were not elucidated.

The difficulties encountered when attempting quantitative work with small amounts of silver were augmented by the presence of various compounds which appear to be constituents of all developed and fixed photographic images. Attempts were made to obtain quantitative results by the use of silver wire, but the action of the "bleaching "baths on the metal in this condition was inordinately slow and the quantitative work was therefore abandoned.

Piper has subsequently (private communication) expressed the opinion that the chromium in the "bleached" silver-chromium complex is in the chromous condition, but the existence of a chromous compound which exhibits reduction reactivity of a degree sufficient to decompose water (see "Reduction methods of volumetric analysis," Knecht and Hibbert, p. 104) in the presence of an energetic oxidiser such as potassium bichromate, appeared to be highly improbable, and the present author therefore endeavoured to determine the state of oxidation of the chromium in the complex.

A carefully prepared silver mirror was used as the "image" and the chromium present in the "bleaching" baths and in the "bleached" image was determined by means of a solution of titanous chloride. The influence of the hydrochloric acid on the bichromate was eliminated by working against a "blank." The mirror showed a metallic silver content of 99·83% (mean of two determinations).

It will be evident that if the silver reduces the chromium to the chromous state only half the weight of bichromate will be reduced as compared with that which would be reduced were the reaction to terminate when the chromic condition had been attained.

Using Eder's formula on 0·3190 grm. Ag it was found that 108 Ag = (a) 7·95 and (b) 8·0124 grms. O from bichromate, and that the whole of the reduced chromium passed into solution in the bleaching bath.

Using the formula B above on 0·1316 grm. Ag. the result 108 Ag = 7·9796 grms. O from bichromate was obtained. In this case a proportion of the reduced chromium compound was attached to the silver chloride. After treating the "bleached" mirror with dilute sulphuric acid it was completely soluble in ammonia solution and the acid liquor contained exactly the amount of chromium which the bleaching bath lacked in order to give the result indicated.

Thus intensification was due to a precipitate of a chromic compound. The conditions, when bath A is used for bleaching, are not quite so simple as in either of the two cases cited above. The amount of CrO_3 apparently reduced is always in *slight excess* of that which would agree with theory. The excess was found to be represented by unreduced CrO_3 which is combined with the precipitate, to which it imparts a brown colour and from which it cannot readily be separated without the use of acid washings.

The brown precipitate appears to be similar to that which is formed when a solution of potassium bichromate is reduced at the boil with an amount of sodium sulphite insufficient to reduce that part of the chromium which forms the *bi*-chromate, *i.e.* the CrO_3 in K_2CrO_4,CrO_3

The colloidal nature of the chromic hydroxide precipitated under these conditions, the relatively small amount of CrO_3 which is attached to it, and the fact that this amount was governed by the final CrO_3 content of the reacting solutions, point to the conclusion that the brown precipitate is an adsorption compound of either CrO_3 or the bichromate and basic chromic hydroxide.

It has been shown that the brown complex of a "bleached" negative whilst being readily attacked by dilute mineral acids is relatively highly resistant towards a 2% aqueous solution of potassium metabisulphite. In this respect it is quite analogous to the brown precipitate formed by the action of sulphite on bichromate. Further the analogy extends to the action of alkaline photographic developers which reduce the CrO_3 in each complex with a resulting change in the colour of the complex from brown or buff to olive green. Eder's solution in conjunction with titanous chloride titration may be used for the estimation of the metallic silver content of photographic images (developed).

THE PREVENTION OF REVERSAL OR SOLARISATION IN PHOTOGRAPHIC NEGATIVES.

BY R. E. CROWTHER.

Of the various conditions which lead to the formation of a reversed result when an exposed photographic emulsion is developed in the ordinary way, this communication deals only with those which may be conveniently grouped under the term "Over Exposure."

Such over exposure may be constituted by abnormally prolonged action of a light of average